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INDEX TO VOL. XIII.

A

Accident at Health Exhibition, 480, 494, 502.
Africa, West, A Cable to, 542, 554.
American Science Association, The, 495.
Ammen, Admiral D., Sounding Apparatus, 457.
Anderson, Sir J., Cables in War Time, 540.
Arago Disc Dynamo, 351.
Artificial Lighting, by R. E. Crompton, 210.
Ayrton and Perry, Professors, New Form of Spring for Meters, 85, 109.

B

B.T.K. System at Colchester, 117, 137, 474.
Bandsept, A., Tubular Carbons, 61.
Barker, E. R., Galvanometer and Battery Test, 247.
Bartholomew's Hospital, Electrical Department, 261.
Batteries, Primary :—
  Crova and Garbe's Standard Cell, 296.
  for Electric Lighting, by I. Probert, 161, 183.
  Lalande and Chaperon's 90.
  Seat of E.M.F. in, by Dr. Lodge, 497.
Batteries, Secondary :—
  Discharge of, by Professor Frankland, 471.
  Electrolysis of Sulphuric Acid in, 234.
  Swan and Brush Patents, 95.
  Their Use in Telegraphy, by W. H. Preece, 498.
  Working Tramcars in Brussels, 94.
  See also CORRESPONDENCE and NOTES.
Battery and Galvanometer Test, 247.
Beetz, W. H., Electrometric Measurements, 394.
Belgium, Long Distance Telephoning in, 560.
Bell, Jenkin's Alarm, for Greenhouses, 203.
Berlin, Cost of Electric Lighting in, 479.
Bidwell, S., Physical Properties of Metals, 35.
Bismuth, Variations in Physical Properties of, 479.
Blakesley, T. H., Currents and Conductors, 106.
Blyth, Professor J., Solenoid Galvanometer, 432.
Body, The, and Currents, 108.
Books, Notices of (*see* REVIEWS).
Boston or Bernstein Lamp, 59.
Bottomley, J. T., Daniell's Cell, 574.
Bottomley, J. T., Loss of Heat by Radiation, 441.
Bottomley, J. T., Permanent Temperature of Conductors, 538, 559.
Boys, C. V., Magneto-Electric Induction, 225, 462.
Brackett's Energy Meter, 80.
Bramwell, Sir F., Address to Section G, British Association, 421.
Breguet's Theory of Dynamos, 280.
Bridge for Measuring Small Resistances, by E. C. Rimington, 89.
Bristol Corporation *v.* United Telephone Company, 192.
British Association Meeting at Montreal :—
  Admiral Ammen on Sounding Apparatus, 457.
  J. T. Bottomley on Loss of Heat by Radiation, 441.
  Sir F. Bramwell's Address to Section G, 421.
  Captain Cardew on a New Voltmeter, 431.
  Professor Frankland on the Discharge of Accumulators, 471.
  Leading Article on, 392.
  Dr. O. J. Lodge on Dust, 459.
  Dr. O. J. Lodge on the Seat of E.M.F. in the Voltaic Cell, 497.
British Association Meeting at Montreal :—
  W. H. Preece on the Watt and Horse-Power, 473.
  W. H. Preece on Secondary Batteries for Telegraphy, 498.
  President's Address, 373.
  Report of Committee on Screw Gauge, 417.
  Sir H. Roscoe's Address to Section B, 400.
  Summary of Proceedings, 470.
  Sir W. Thomson's Address to Section A, 397.
  Sir W. Thomson on a Gyrostatic Compass, 492.
Brush Dynamo, The, 304.
Brush and Swan Accumulator Patents, 95.
Brussels, Electric Lighting of the Grand Place, 396.
Brussels, Tramcars Worked by Accumulators in, 94.
Bucharest, Electricity in, 577.
Bürgin Dynamo, The, 305.

C

Cable Maintenance, One Phase of (Leading Article), 534.
Cable Stories, Old, by F. C. Webb, 55, 203, 272, 365, 415, 436, 510.
Cable Testing, by H. C. Mance, 21.
Cable to West Africa, 542, 554.
Cables, Submarine, Protection of, 10, 36.
Cables in War Time, by Sir J. Anderson, 540.
Cambrian Railways and Postmaster General, 330.
Carbon, Electro-deposition of, by Dr. Gore, 340.
Carbons, Tubular, by A. Bandsept, 61.
Cardew, Captain, New Voltmeter, 431.
Carus-Wilson's Electric Governor, 226.
Cary's Telephone Signal, 512.
Cauderay's Electric Meter, 439.
Chandler, Professor, Electricity and Magnetism, 18.
Chemical Corrosion and Voltaic Current, by Dr. G. Gore, 30.
Chlorate of Silver, Electrolysis of, by Dr. Gore, 341.
City and Guilds Institute, The :—
  Examination Papers, 160, 182.
  Leading Article on, 204.
  Programme of Central Institution, 414, 419.
  Technical College at Finsbury, 181.
Clock Setting Mechanism, Kettell's, 453.
Coast Defence, Williams's System of, 518.
Colchester, B.T.K. System at, 117, 137, 474.

COMPANIES' MEETINGS, REPORTS, &c. :—
  Anglo-American Brush, 288.
  Anglo-American Telegraph, 287, 308.
  Brazilian Submarine Telegraph, 544, 580.
  Consolidated Telephone, 70, 285.
  Cuba Submarine Telegraph, 287, 312, 330.
  Direct Spanish Telegraph, 444, 483.
  Direct United States Cable, 236, 283.
  Eastbourne Electric Light, 311.
  Eastern Telegraph, 215, 236.
  Eastern Extension Telegraph, 504, 522.
  Faure Accumulator, 144, 216.
  Globe Telegraph, 264, 284.
  Great Western Electric Light, 484, 503.
  India Rubber, 263.
  Lancashire and Cheshire Telephone Exchange, 332.
  Lancashire Maxim-Weston Electric, 46.
COMPANIES' MEETINGS (*continued*):
  London Platino-Brazilian Telegraph, 43.
  Maxim-Weston Electric, 45.
  National Telephone, 312, 331.
  Pilsen Joel Electric Light, 379.
  River Plate Telephone, 72, 355.
  Submarine Cables Trust, 24.
  Submarine Telegraph, 287, 310.
  Telegraph Construction, 263.
  Telephone Company of Ireland, 524, 544.
  United Telephone, 239.
  West Coast of America Telegraph, 236, 262.
  West India and Panama Telegraph, 44, 524, 543.
  West Middlesex Electric Light, 264.

Compass, Gyrostatic Model of, by Sir W. Thomson, 492.
Condenser, Measuring the Capacity of, 297.
Conductors and Currents, by T. H. Blakesley, 106.
Conductors, Economical, by W. L. Hooper, 274.
Conductors and Heating, by Professor G. Forbes, 16, 39, 63, 82.
Conductors, Permanent Temperature of, by J. T. Bottomley, 538, 559.
Congress, Electrical at Philadelphia :—
  Report of Discussions, &c., 454, 459, 477.
  Professor FitzGerald on the Theory of the Dynamo, 558.
  Professor Rowland's Address as President, 481, 500.
  Professor Rowland on the Theory of the Dynamo, 516, 635.
Copper-Oxide Battery, Lalande and Chaperon's, 90.
Cores, Induction in, by O. Heaviside, 54, 103, 133, 199, 333, 362, 386, 430.

CORRESPONDENCE TO "THE ELECTRICIAN :"—
  Accident at Health Exhibition, 493.
  Accumulators (*see* BATTERIES, Secondary).
  Allbright, J. F., Electric Lighting for Lighthouses, 320.
  Allbright, J. F., Lamps with Dynamos and Batteries, 254.
  Aldred, W., What is Electricity ? 393.
  Avertisseur Electro-Automatique, 436.
  Ball's Unipolar Dynamo, 515.
  Bain, Alexander, 179.
  Banks, W., Electric Launch Trial, 456.
  Batteries, Primary :—
    FitzGerald's Method of Measuring Internal Resistance, 393.
    For House Lighting, 205, 254, 277.
  Batteries, Secondary :—
    F. S. V. at Bristol, 58.
    Gadot's Improvements in F.S.V., 320.
    Zinc-Lead, 37.
  Blakesley, T. H., Electro-Dynamics, 277.
  Braithwaite, J. B., Accumulators, 58.
  Bright, Sir C. T., Siemens' Electro Dynamometer, 345.
  Capito, C., Electric Launch, 435.
  Central Station Lighting, 58.
  City and Guilds Telegraphy Examination, 346.
  Condenser, Capacity of, 345.
  Consolidated Telephone Company's Meeting, 320.
  Conversazione at King's College, The Lighting at, 254.
  Crompton, R. E., Cost of Electric Lighting, 154.
  Cruto Lamp, 127.
  Current Carrying Capacity of Wires, 178, 206, 345.

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CORRESPONDENCE (*continued*):
Current, Passage of, through a Conductor, 394.
Currents, Accidents from, 109.
Davey, Edward, 533.
Davey, St. G. W., The Roussy Moderator, 555.
Deane, H. P., Inventions Exhibition, 475.
Dundee Telephone Company, 475, 493, 533.
Dunston, R. E., The Roussy Moderator, 555.
Dynamometers, 229.
Dynamos:—
Ball's Unipolar, 515.
v. Batteries, 205, 254, 277.
Calculating the Relation of Resistances, 253.
Compound, 455.
Dimensions of, 475.
Formulæ, &c., Wanted, 299.
The Phœnix, 155.
Small Gramme, 277.
Earth as a Return Wire, 555.
Electric Lighting:—
Act, The, 176, 229, 515, 533.
The Common Sense of, 176.
Cost of, 127, 154, 175.
Gaulard-Gibbs and Gordon, 321, 346.
at King's College Conversazione, 254.
Leads, Rise of Temperature in, 155, 178, 206, 345.
for Lighthouses, 320.
Moderator, Roussy's, 555.
by Primary Batteries, 205, 254, 277.
Electricity, Nature of, 153, 179, 345, 393.
Electro-Dynamics, 277.
Electro-Magnet, New Form of, 515.
Engine, The Electric: A Recipe, 555.
Ewing, J. A., Cost of Electric Lighting, 154, 175, 206.
Exhibitions:—
Health, Accident at, 493.
Health, Professor Forbes' Report on, 455.
Inventions, 475.
Fahie, J. A., Cost of Electric Lighting, 154, 175.
Fahie, J. J., Honour to Whom Honour is Due, 533.
FitzGerald, D. G., Nature of Electricity, 153, 179.
FitzGerald, D. G., Potential and Charged Conductors, 127.
FitzGerald's Method of Measuring Internal Resistance of Batteries, 393.
Fleming, J. A., Current Carrying Capacity of Wires, 178.
Fleming, J. A., Electric Lighting Act, 177.
Fleming, W. H., Lightning Conductors, 206.
Forbes, Professor, his Report on Health Exhibition, 455.
Frost, A. J., Alexander Bain, 179.
Gaulard-Gibbs System, 321, 346.
Goolden, W. T., Cost of Electric Lighting, 155.
Gordon's Book, 58.
Gramme Dynamo, Small, 277.
Grundy, A., Accident at Health Exhibition, 493.
Grundy, A., Non-Magnetisable Watch, 456.
Hammersley, G., Solenoidal Action, 37.
Hawker's Photometer, 253.
Heaviside, O., Capacity of a Condenser, 345.
Hedges, K., Current Carrying Capacity of Wires, 206.
Honour to Whom Honour is Due, 533.
Hospitalier, E., Speed of Wheatstone Instrument, 475.
Incandescence, 58.
Incandescent Lamps, Gérard's, 155.
Induction, Curious Case of, 515, 533.
Iron and Steel Wires, Stress and Resistance of, 85.
Jenkin, F., Telpherage, 127.
Joel, H. F., The Pilsen Company, 397.
Jones, R. C., Ruhmkorff's Coil, 179.
Kemp, H. R., Fitzgerald's Method of Measuring Internal Resistance of Batteries 393.
Kent, H. A., Ball's Unipolar Dynamo, 515.
Kent, H. A., Zinc-Lead Accumulators, 37.
Kingsland, W., Cost of Electric Lighting, 176.
Launch, Banks's Electric, 435, 456.
Leads, Electric Light, Rise of Temperature in, 155.
Ledingham, L. N., Weight Voltameter, 412.
Legal Question *re* Telephones, 533.
Light Tables, Artificial, 58.
Lighthouses, Electric Lighting for, 320.

CORRESPONDENCE (*continued*):
Lightning Conductors, 85, 206, 533.
Lightning and Trees, 456.
Martin, W. C., Cost of Electric Lighting, 127, 175, 206.
Martin, W. C., Electric Lighting Act, 229.
Massey, W. H., Artificial Light Tables, 58.
Miller, L., Compounding Dynamos, 455.
Miniature Installations, 570
Munro and Jamieson's Pocket Book, 155, 178, 345.
Patent Law, 515.
Paterson and Cooper, Phœnix Dynamo, 155.
Phœnix Dynamo, 155.
Photometer, Hawker's, 253.
Pilsen-Joel Company, The, 393.
Potential and Charged Conductors, 127.
Purnell, S., What is Electricity? 345.
Railway and Electric Appliances Company, 13.
Reckenzaun, A., Improvements in Accumulators, 320.
Relays, 455.
Resistance of Wires, Influence of Stress on, 85.
Resistances of Dynamos, Calculating Relation of, 253.
Ross, O. C. D., Batteries for House Lighting, 205, 277.
Roussy's Electric Light Moderator, 555.
Ruhmkorff's Coil, 179.
Shaw, F. J., Dimensions of Dynamos, 475.
Siemens's Electro-Dynamometer, 345.
Sims's Mechanical Telephone, 516.
Solenoidal Action, 37.
Sprague, J. T., New Form of Electro-magnet, 515.
Stone, W. H., Accidents from Currents, 109.
Supplement No. 5, A Correction, 346.
Telegraphy, Earth as a Return Wire, 555.
Telpherage, 127.
Telephone at Dundee, 475, 493, 533.
Telephone—A Legal Question, 533.
Telephone, Sims's Mechanical, 516.
Telephones, The Use of in England, 515.
Telephoning Extraordinary, 394.
Telephony, Practical, 369, 435.
The Healtheries Fountains, 570.
Tomlinson, H., Stress and the Resistance of Wires, 85.
Trees and Lightning, 456.
Trotter, A. P., Dynamometers, 229.
Units, Electrical, 37, 277.
Volk, Magnus, Non-magnetisable Watches, 436.
Volk, Magnus, Practical Telephony, 435.
Voltameter, Weight, 412.
Watch, Non-magnetisable, 436, 456, 475.
Webster, R., Non-magnetisable Watches, 475.
Wheatstone Automatic, Speed of, 455, 475.
White, Arnold, Electric Lighting Act, 176.
Whiteman, W. T., Patent Law, 515.
Williams, J. S., Railway and Electric Appliances Company, 13.
Willans, J. W., The Electric Engine, 555.
Wires, Current Carrying Capacity of, 178, 206.
Wires, Influence of Stress on Resistance of, 85.
Wires, Overhead, 13.
Worsey, C. H., Solenoidal Action, 37.
Wright, A., Incandescence, 58.
Zinc, Amalgamated, Who First Used it, 369.
Zinc-lead Accumulators, 37.

Correspondents, Answers to, 108, 132, 322, 344, 414, 474, 534.
Crawley and Rimington, Electric Light Engineering, 270, 294, 318, 342, 363, 390.
Criterion Theatre, Electric Light at, 490.
Crompton, R. E., Artificial Lighting, 210.
Crompton-Crabb Arc Lamp, 33.
Crova and Garbe's Standard of Potential, 296.
Currents and the Body (Leading Article), 108.
Currents, Patents for regulating, by C. A. Stephenson, 225.

D

Daniell's Cell, 574.
Darwin's Dynamometer, 8.
Davey, Edward, His Claims to Justice, 520.
Davey Paxman and Company's Exhibits at Health Exhibition, 301, 438.

DEATHS:—
Fawcett, The Right Hon. Mr., 573.
Pulvermacher, J. L., 435.
Sabine, Robert H., 573.

DEATHS (*continued*):
Volckmar, Ernest, 258.
See also NOTES.
Devon and Cornwall Electric Light Co., Re., 215.
Diehl's Incandescent Lamp, 279.
Direct Cable Company *v.* Muirhead, 168.
Drawbaugh Telephone Case, The, 511.
Dudley, W. L., Iridium Industry, 234.
Dust, by Dr. O. J. Lodge, 459.
Dynamometers, Mechanical, by G. Kapp, 8, 79, 201.
Dynamos:—
Accident at Health Exhibition, 480, 494, 502.
Edison-Hopkinson, 325.
Fein's Hand Machine, 319.
Field Magnets of, Von Waltenhofen on, 38.
New Unipolar, by J. M. M. Munro, 550.
Patents for Controlling, by C. A. Stephenson, 225.
Sprague's Report on, 231, 259, 280, 304, 323, 351.
Theory of, by Prof. J. FitzGerald, 558, 576.
Theory of, by Prof. Rowland, 516, 535.
See also CORRESPONDENCE and NOTES.

E

Eastern Company and Central News, 12, 168, 214.
Edison Dynamos, 324.
Edison Station in Milan, 248.
Edison-Hopkinson Dynamo, 325.
Edison-Swan Exhibits at Health Exhibition, 302.
Educational Campaign, The Coming (Leading Article), 414.
Electric Alarm for Greenhouses, 203.
Electric Fittings, His, by Mho, 158.
Electric Jewellery, Trouvé's, 250.
Electric Light Engineering, by Crawley and Rimington, 270, 294, 318, 342, 363, 390.
Electric Lighting:—
Accident at Health Exhibition, 480, 494, 502.
in Berlin, Cost of, 479.
at Brewers' Exhibition, 553,
at Colchester, 117, 137, 474.
Cost of (Leading Article), 156,
at Criterion Theatre, 490.
by R. E. Crompton, 210.
at the Dairy Show, 513.
Edison Station in Milan, 248.
Examination Paper on, 160, 182.
Finance of (Leading Article), 228.
in Flour Mills, by J. H. Greenhill, 157.
in the Grand Place, Brussels, 396.
at Greenock, 353.
at Health Exhibition (*see* EXHIBITIONS).
Incandescent by T. H. S. Hawker, 151, 207, 246, 347.
for Lighthouses, Trinity House Experiments, 349 (*see* also NOTES).
for Outdoor Recreation (Leading Article), 276.
Primary Batteries for, by I. Probert, 161, 183.
on the "Richelieu," 450.
from a Sanitary Point, by J. A. Fahie, 520.
at Terni, 250, 279.
Times Correspondence on, 423, 433.
at Turin (*see* TERNI).
for War Purposes, 282.
See also CORRESPONDENCE and NOTES.
Electric Lighting Act, The (Leading Article), 180, 228.
Electrical Department of Bartholomew's Hospital, 261.
Electrical Energy, Transformation of, 278.
Electrical Instrument Making, Examination Paper on, 161, 182.
Electrical Testing Establishment, 295.
Electricity: Its Passage through Gases, 212.
Electricity and Light, by J. T. Sprague, 7, 81, 135, 224.
Electricity and Magnetism, by Prof. Chandler, 18.
Electricity as a Motive Power on Railways, 552.
Electricity as a Natural Force, by E. L. Voice, 531.
Electricity in Bucharest, 577.
Electro-Chemistry, by Dr. G. Gore, 6, 78, 102, 126, 150, 174, 198, 222.
Electro-Dynamics, by J. W. Nystrom, 258.

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Electrolysis of Fluoride of Silver, by Dr. Gore, 341.
Electrolysis, New Phenomena in, by Dr. Gore, 59.
Electrolysis of Sulphuric Acid in Accumulators, 234.
Electro-Magnetic Ore-Dresser, 326.
Electrometric Measurements, by W. H. Beetz, 394.
Electromotive Forces in the Voltaic Cell, Seat of, by Dr. O. J. Lodge, 497.
Elwell-Parker Engine, 540.
Engines, Patents, for Controlling, by C. A. Stephenson, 225.
Examination Papers at City and Guilds Institute, 160, 182.
Exhibitions :—
  Antwerp, 516.
  Health—
    Accident at, 480, 494, 502.
    Awards at, 565.
    Davey, Paxman's Exhibits at, 301, 438.
    Edison-Swan Exhibits at, 302.
    Professor Forbes's Report on, 442.
    The Fountains, 456.
    Gülcher Exhibits, 388.
    Hammond Company's Exhibits, 347.
    Pilsen Company's Ehibits, 556.
    Preliminary Remarks on, 206, 229, 254, 273.
    Siemens's Exhibits, 346.
    Woodhouse and Rawson's Exhibits, 412, 439.
  Inventions, 305, 368, 514.
  Philadelphia, 450, 475, 496, 511, 552, 571.
  See also NOTES.

F

Fahie, J. A., Electric Lighting from a Sanitary Point, 520.
Fein's Hand Dynamo, 319.
Finsbury Technical College, 181.
Fittings, His Electric, by Mho, 158.
FitzGerald, Professor J., Theory of the Dynamo, 558.
Flour Mills, Electric Light in, by J. H. Greenhill, 157.
Fluoride of Silver, Electrolysis of, by Dr. Gore, 341.
Forbes, Professor, Conductors and Heating, 16, 39, 63, 82.
Forbes, Professor, Report on Health Exhibition, 442.
Fountains at the Health Exhibition, 456.
Frankland, Professor E., Discharge of Accumulators, 471.
Froude's Dynamometer, 80.

G

Gale, H. B., Efficiency of Incandescent Lamps, 255, 305, 350.
Galvanometer and Battery Test, 247.
Galvanometer, Solenoid, by Professor J. Blyth, 432.
Galvanometer, Standard Tangent, by S. P. Thompson, 478.
Gases, The Kinetic Theory of, 397.
Gases, The Passage of Electricity through, 212.
Gladstone and Tribe, Electrolysis of Sulphuric Acid, 234.
Glass, Solid, Electrolysis of, 391.
Glazebrook, R. T., Measuring the Capacity of a Condenser, &c., 297.
Globe Lightning, by G. Planté, 366.
Gordon's Magnetic Field Measurer, 34.
Gore, Dr. G., Chemical Corrosion, 30.
Gore, Dr. G., Electro-Chemistry, 6, 78, 102, 126, 150, 174, 198, 222.
Gore, Dr. G., Electro-Deposition of Carbon, 340.
Gore, Dr. G., Electrolysis of Fluoride of Silver, &c., 341.
Gore, Dr. G., New Phenomena in Electrolysis, 59.
Gostkowski, Baron, Electricity and Railways, 552.
Governor, The Porte-Manville Electric, 367.
Gramme Dynamos, 280, 352.
Great Western Electric Light Company, *re*, 307.
Greenhill, J. H., Electric Light in Flour Mills, 157.
Greenock, Electric Lighting at, 353.
Gülcher Company, *re*, 354.
Gülcher Company's Exhibits at Health Exhibition, 388.

H

Hall's Phenomenon in Liquids, 391.
Hall's Phenomenon, by H. Tomlinson, 63.
Hammond Company's Exhibits at Health Exhibition, 347.
Hawker, T. H. S., Incandescent Lighting, 151, 207, 246, 347.
Heat, Loss of, by Radiation, &c., by J. T. Bottomley, 441.
Heating of Conductors, by Professor G. Forbes, 16, 39, 63, 82.
Heaviside, O., Induction in Cores, 54, 103, 133, 199, 338, 362, 386, 430.
Hefner-Alteneck's Dynamometer, 202.
Hipp's Microphone, 513.
Hooper, W. L., Economical Conductors, 274.
Horse-power, by W. H. Preece, 473.
Hospital, Bartholomew's, Electrical Department of, 261.
Hospitalier, E., Transformation of Electrical Energy, 278.
Houston, Professor E. J., Synchronous Multiplex Telegraphy, 410.
Huron, M., Physical Properties of Bismuth, 479.

I

Imperial Defences and the Telegraph, 554.
Incandescent Lamps :—
  Boston or Bernstein, 59.
  Consolidated Company's, 119.
  Diehl's, 279.
  Efficiency of, by H. B. Gale, 255, 305, 350.
  Roussy's Moderator for, 542.
  Tubular Carbons for, 61.
Incandescent Lighting, by T. H. S. Hawker, 151. 207, 246, 347.
Induction in Cores, by O. Heaviside, 54, 103, 133, 199, 338, 362, 386, 430.
Induction, Magneto-Electric, by C. V. Boys, 225, 462.
Induction, by Willoughby Smith, 138.
Inventors' Institute, 192.
Iridium Industry, by W. L. Dudley, 234.

J

Jablochkoff Company *v.* Howard, &c., 262.
Jenkin, Professor F., Telpherage, 41, 66.
Jenkins's Alarm for Greenhouses, 203.
Jewellery, Trouvé's Electric, 250.
Joke, a Telegrapher's, 372.
Joule, Dr., his Life and Work, 370.

K

Kapp, G., Mechanical Dynamometers, 8, 79, 201.
Kettell's Clock Setting Mechanism, 453.

L

Lalande and Chaperon's Battery, 90.
Lancashire and Cheshire Telephone Company *v.* Manchester Overseers, 215.
Lane Fox's Regulator, 226.

LEADING ARTICLES :—
  Accidents from Lightning, 252.
  British Association, 392.
  Cable Maintenance, one Phase of, 534.
  City Guilds, The, 204.
  Cost of Electric Lighting, 156.
  Dangerous Dynamos, 494.
  Deferred Telegrams, 60.
  Educational Campaign, The Coming, 414.
  Electric Currents and the Human Body, 108.
  Electric Light for Outdoor Recreation, 276.
  Electric Lighting Act, The, 180.
  Electric Lighting at Colchester, 474.
  Electrical Congress at Philadelphia, 454.
  Finance of Electric Lighting, The, 228.
  Forbes, Professor, his Report on Health Exhibition, 434.
  Imperial Defences and the Telegraph, 554.
  International Inventions Exhibition, 368.
  Lighthouses, Electric Lighting for, Trinity House Experiments, 349.
  Lightning Conductors, 344.
  Patent Rights, International, 514.

LEADING ARTICLES (*continued*):
  Post Office and the Telephone, 132.
  Submarine Cable Convention, 36.
  Sweetness and Light, 572.
  Telegraph, The, and Colonial Federation, 300.
  Telegraphs and News Agencies, 12.
  Telephone Companies' Grievances, 84, 322.

LEGAL :—
  Bristol Corporation *v.* United Telephone Company, 192.
  Brush Company *v.* United States Company, 283.
  Brush Midland Company, 262.
  Central News *v.* Eastern Telegraph Company, 168, 214.
  Clark *v.* Bennett, 191.
  re Devon and Cornwall Electric Light Company, 215.
  re Great Western Electric Light Company, 307.
  re Gülcher Company, 354.
  Jablochkoff Company *v.* Howard, &c., 262.
  Lancashire and Cheshire Telephone Company *v.* Manchester Overseers, 215.
  Metcalf *v.* London and Globe Company, 307.
  Muir and Co. *v.* Anglo-American Brush Company, 23, 190.
  Muirhead *v.* Direct Cable Company, 168.
  Postmaster-General *v.* Cambrian Railways, 330.
  re South Eastern Brush Company, 330.
  Swan *v.* Brush, Accumulator Patents, 95.
  United Telephone Company *v.* Graham, 307.
  United Telephone Company *v.* Hebden, 43.
  United Telephone Company *v.* London and Globe Company, 23, 307.
  re Universal Electric Company, 236.
  Wandsworth Board *v.* Postmaster-General, 43.
  Wandsworth Board *v.* United Company, 22, 142.
  See also NOTES.

Light, Electricity and, by J. T. Sprague, 7, 81, 135, 224.
Light Tables, Artificial, by A. P. Trotter, 38.
Lighting, Artificial, by R. E. Crompton, 210.
Lightning :—
  Accidents from, 252, 327, 354.
  Conductors (Leading Article), 344.
  Conductors, Toepler's Experiments, 326.
  Flashes, 350.
  Globe, by G. Planté, 366.
  Rods, Siemens' Apparatus for Testing, 369.
  and Telegraph Material in France, 255.
  and Trees, 397.
Liquids, Hall's Phenomenon in, 391.
Literature (*see* REVIEWS).
Lodge, Dr. O. J., Dust, 459.
Lodge, Dr. O. J., Seat of E.M.F. in the Voltaic Cell, 497.
Lontin Dynamo, The, 352.

M

Magnetic Field Measurer, Gordon's, 34.
Magnetism and Electricity, by Prof. Chandler, 18.
Magneto-electric Induction, by C. V. Boys, 225, 462.
Magnets, Field, of Dynamos, Von Waltenhofen on, 38.
Mance, H. C., Cable Testing, 21.
Matter, Kinetic Theory of, 397.
Maxim Dynamo, The, 304.
Measurements, Electrometric, by W. H. Beetz, 394.
Measuring Instruments, New Form of Spring for, by Profs. Ayrton and Perry, 85, 109.
Metals, Physical Properties of, by S. Bidwell, 35.
Meter, Cauderay's, 439.
Microphone, Hipp's New, 513.
Milan, Edison Station in, 248.
Mills, Electric Light in, by J. H. Greenhill, 157.
Miners' Safety Lamp Competition, 282.
Mines, Electrical Transmission of Power in, 551.
Moseley's Transmitter, 136.
Multiplex Telegraphy, Synchronous, 410.
Munro, J. M. M., Unipolar Dynamos, 550.

N

News Agencies and Telegraphs, 12.

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NOTES :—
Accident at the Health Exhibition, 506.
Adulteration Detected by Electrolysis, 445.
Africa, South, Cable to, 509, 527.
Alloys, Testing, by Electricity, 314.
Alternate-Current Machines, Self-Induction in, 509.
Aluminium, Resistance of, 465.
America, Government Telegraphs in, 97.
American Institute of Electrical Engineers, 52, 407.
American Telegrams, 445.
An Evil and its Remedy, 568.
A New "Ism," 566.
Appointments :—
Ayrton, Prof., Physics Chair, City and Guilds Institute, 50.
Baker, C. H., Manager, C. and S. American Company, 445.
Graham, H. C., Manager, Electric Apparatus Company, 25.
Harrison, T. H., Agent to Gülcher Company, 333.
Highton, T. A., Secretary, Piccadilly Art Galleries, 49.
Martin, W. C., Manager, E. M. F. Company, 334.
Otway, A., Telegraphs Superintendent at Cairo, 485.
Arc Lamp, An Improved, 445.
Arc Lamps on Incandescent Circuits, 171.
Arc Lamps, Siemens' Small, 122, 525.
Arc, Resistance of, 27.
Arc Spectra, 315.
Asia, Central, Telegraphic Extension in, 121.
Atlantic Cables, New, 1, 50, 73, 97, 170, 194, 241, 313, 333, 357, 406, 465, 485, 488, 528.
Atmospheric Dust and Auroræ, 172.
Atmospheric Electricity, 75, 244.
Atmospheric Phenomena, 289.
Aurora in High Latitudes, Greely's Observations, 334.
Auroræ and Atmospheric Dust, 172.
Australia, Cable to, *vià* the Cape, 509, 527.
Australia, South, Rules for Cipher Messages, 546.
Australia, The Tariff Question in, 27, 97, 121.
Austrian Telegraph Statistics, 445.
Balloon Corps, Formation of, 50.
Balloons, Electric Propulsion of, 313, 335, 359, 382, 445, 466, 486, 507.
Balloons, Speed of, 548.
Batteries, Primary :—
Becquerel's Dry Cell, 218.
Carbon for, 170.
Electricity Free of Cost, 99.
Franks' Granule Carbon, 468.
An Iron Carbon, 171.
Peroxide of Lead Cell, 243, 314.
Pierre's Single Fluid, 427.
Riatti's Thermo-Electric, 546.
Tomassi and Radiguet's Carbon, 290.
Batteries Secondary :—
Benton's Iron Cell, 123.
Brush and Swan Patents, 74.
Gadot's Improvements in, F.S.V., 290.
New Type of, F.S.V., 26.
O. J. L. on, 549.
Parod's Improvements, 505.
Reynier's Zinc Lead, 2, 449.
Belgian Army Telegraph Corps, 425, 445.
Bell Telephones, Output of, 121.
Bellati's Automatic Regulator, 425.
Bellati's Electro-Dynamometer, 26.
Belts, Current Generated by, 467.
Bennett-Mackay Cables, The, 1, 50, 73, 170, 194, 241, 313, 333, 357, 406, 465, 485, 488, 528.
Benton's Iron Cell, 123.
Bichromate of Potash, Roemer's Process, 406.
Binko, H. B., Bankruptcy of, 547.
Bismuth, Influence of Heat, &c., on, 409, 447.
Blackburn's Testing Apparatus, 486.
Blasting in Continental Collieries, 51.
Bokhara, Telegraph Line to, 382, 405, 485.
Bontemps, C., Death of, 26.
Boracite, Pyro-Electric Properties of, 196.
Boycotting the Monday Pops., 567.
Brake, Walcker's Electric, 333.
British Association in 1854, 407.
British Association at Montreal, 99, 337, 357, 445.
Brush Company of Scotland, 3.
Brush Patents, The, 336.

NOTES (*continued*):
Brush System :—
in Belfast Bleach Works, 467.
in Bjorneborg Theatre, 465.
in Driffield Oil Works, 465.
on Ships, 466, 529.
in Temesvar, 464, 507.
Brush and Swan Accumulator Patents, 74.
Brussels Electrical Companies, 485.
Brussels Mail Carts, Electric Alarms for, 381.
Brussels Theatre, Telethermometer at, 407.
Business Notices, 73, 265, 290, 486, 505, 525.
Cable to Australia *vià* the Cape, 509.
Cable, the Dover-Calais at Turin, 466.
Cable Management, American Opinion of, 358.
Cable, a Whale Caught by, 316.
Cablegrams, the Milking of, 3.
Cable Ship, New, the Mackay-Bennett, 425.
Cables :—
French, 406.
Hemp, Baker's Patent, 49.
Interrupted, 1, 49, 73, 145, 465, 485, 488.
New, 1, 49, 73, 97, 146, 169, 170, 193, 194, 241, 267, 290, 313, 333, 357, 406, 407, 425, 426, 465, 485, 488, 527, 528.
Protection Convention, 121.
Repaired, 73, 97, 145, 241, 357, 485, 525, 545.
Carbon for Batteries, 170.
Carbon Battery, Tommasi and Radiguet's, 290.
Cardew's System of Winding Dynamo Magnets, 100, 487.
Carré Carbons, Agents for, 425.
Cataract Lighted by Electric Light, 359.
Catastrophe at Glasgow, The, 566.
Cathodes, Unequal Resistance at, 468.
Cellulose, Electrolysis of, 548.
Central News *v.* Eastern Telegraph Company, 3.
Chemical Industry, Electricity Applied to, 489.
Chess by Telephone, 466.
China, Rates to, 74, 169, 239, 357.
China, the War and the Telegraph in, 381, 405, 465.
Cholera and Electricity, 358.
Cholera and the Telephone, 547.
Chrysanthemums and Electric Light, 565.
City and Guilds Institute, the Central Institution, 73, 146, 149.
Civil Engineers, the Institution of, Medals Awarded by, 217, 549.
Clubs and Telegraphic News, 122.
Clubs, Telephonic Communication with, 171.
Coaling Stations, the Defence of, 527.
Collieries, Electric Light in, 27.
Collieries and Lightning, 5, 77, 335.
Comets' Tails, 429.
Companies, Electrical, in Brussels, 485.
Companies, Joint-Stock, Struck off Register, 170.
Companies, New, 171, 289.
Companies to be Wound up, 25, 73, 97, 145, 169, 193, 241, 265, 289, 313, 333, 357.
Compressed Air, Electricity *v*, 383.
Conference, Electrical, at Philadelphia, 121, 384.
Conversazione at Sir D. Cooper's, 171.
Copper in Arizona, 313.
Creil Experiments, The, 567.
Current, Transmission of to a Distance, 505, 529.
Currents, Deaths Caused by Intense, 408.
D'Arsonval, M., Legion of Honour for, 217.
Deaths from Intense Currents, 408.
Deaths : —
Arnoux, A., 333.
Bontemps, C., 26.
Cross, W., 565.
Edison, Mrs., 383.
Meyer, H. B., 333.
Moigno, Abbé, 219, 244.
Porter, Rufus, 425.
Rego, Captain, 73.
Sabine, T. R., 97.
Trabue, G. W., 25.
Watts, H., 170.
Décharme's Experiments in Coloured Rings, 446.
Delaurier's Induction Lamp, 505.
Deprez's Electric Synchroniser, 469.
Deprez's Experiments at Creil, 26, 98, 265, 547.
Dover-Calais Cable at Turin, 466.
Driving Belts, Current Generated by, 457.
Dundee Mechanical Society, 100.
Dust and Auroræ, 172.

NOTES (*continued*):
Dynamos :—
Cardew's System of Magnet Winding, 100, 487.
Covering the Leads of, 507.
Damoiseau and Petitpont's New, 147.
Edison's Ship Machine, 405.
Manufacture of the Hochhausen, 25.
the Priority Question, 99.
Self Induction in Alternate Current, 509.
for Telegraph Lines, 445.
a Very New One, 526.
Earth Connection, Halitz's Improved, 406.
Earth Currents, Blavier's Book, 2.
Earth Currents, Hissink's Observations, 267.
Earth Currents, Wild's Experiments, 125.
Earthquakes, 26, 50, 73, 97, 121, 145, 146, 193, 242, 265, 289, 314, 316, 333, 357, 381.
Earth's Magnetism, H. at Oxford, 74.
Earth's Magnetism, H. at Paris, 333.
Earth's Magnetism, the Paris Observatory, 407, 446.
Eastern Telegraph Company and Central News, 3.
Eastern Telegraph Company at Turin, 425.
Edison on Electrical Applications, 427.
Edison Lamp, Alleged Fire Caused by, 526.
Edison System :—
in Berlin, 313, 405, 548.
at Brünn, 525.
in Bucharest Theatre, 549.
in Chicago, 121.
in French Factories, 98, 549.
at Geneva, 546.
in Hatchett's Hotel, 405.
on Inner Circle Railway, 487.
in Lausanne Hospital, 289.
in Milan Theatre, 145.
in Mills, 313.
in Paris, 25, 97, 265, 266, 445, 465.
on Ships, 25, 241, 467.
in Stuttgart Theatre, 146.
in Turin Theatre, 49.
in Washington, 25.
Edison's New Ship Dynamo, 405.
Eddystone, Communication with, 73, 446.
Eddystone Lighthouse, The Old, 445.
Egypt, The Telegraphs in, 1, 25, 73, 333, 406.
Electric Boiler Alarm, 569.
Electric Burglar and Fire Alarm, 566.
Electric Discharges in Gases, 445.
Electric Lighting :—
at Antwerp Exhibition, 546, 547.
at Astley Bank, 74.
and Athletic Sports, 289.
at Atlantic Works, Manchester, 527.
in Berlin Houses of Parliament, 98.
in Birmingham Town Hall, 381.
in Bleach Works, Belfast, 467.
in Boiler Works, South Shields, 545.
at Bonn Station, 546.
at Brighton Corn Exchange, 468, 526.
in Brighton Pavilion, 290, 525.
at British Museum, 381.
in Brünn Factories, 525.
in Canary Islands, 27.
in Carriages, 547.
in Chatham Barracks, 357.
in Chicago, Careless Wiring, 28.
and Chrysanthemums, 548.
in Church, 334.
in the City, 546.
in Collieries, 27.
in Cooke's Circus, 505.
in Corngreve's Works, 241.
Correspondence to *The Times*, 292, 337.
at Craig-y-Nos Castle, 315.
in Criterion, Barrow, 122.
at Dances, 99, 220, 467.
in the Distillery, 566.
On Dover Pier, 265.
in Driffield Oilworks, 465.
at Dublin Fête, 485.
at Dundee Exhibition, 465.
at Eastbourne, 567.
on the Embankment, 50, 121.
at Essaud Frères Works near Criel, 545.
in Factories, 98, 549.
in Finland Tannery, 194.
and the Franchise Bill, 507.
in Franco-Chinese War, 426.
in Free Library, Nottingham, 2.
in Furness District, 406.
and Gas, 100, 266, 268, 313, 406, 509, 528.

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NOTES (*continued*):
Electric Lighting:—
in Glassworks, New Cross, 50.
in Government Office, Washington, 25.
in the Grand Place, Brussels, 485.
on the Grand Quai, Geneva, 546.
Hammond Company's Offer to Brighton Corporation, 408.
at Harrogate, 565.
in Hatchett's, Paris, 465.
in Havre Docks, 50.
at the Health Exhibition, 4, 50, 196.
at Hell Gate, 567.
in Hotels, 193, 405, 506, 545.
in the House of Commons, 99.
for the House of Lords, 147.
the Hull Contract, 75, 123, 242.
on Inner Circle Railway, 487.
in Java, 25.
Kensington Order Revoked, 289, 333.
for Lambeth, 269.
at Larard's Still, Manchester, 217.
in Lausanne Hospital, 289.
at the Law Courts, 359, 526, 546.
at Leipsic Panorama, 381.
on Liberty Statue, 405, 525.
in Libraries, 505.
for Lighthouses, 76, 121, 219, 290, 334, 381, 405, 429, 446, 466.
at Linden Park, 101.
to be Discontinued in Liverpool, 49.
at Llanelly Exhibition, 506.
for Locomotives, 357, 405, 425, 468.
at Mayence Station, 405.
in Melbourne Parliament Houses, 51, 194.
Memoranda, 567.
in M. Menier's House, 219.
in Mills, 26, 97, 121, 173, 195, 357, 425, 447, 525.
in Mines, First Attempts, 26.
a Miniature Installation, 526.
at New Orleans Exhibition, 526.
in New York, Cost of, 2.
and New York Steam Company, 446.
in Paris Arts Club, 25.
in Paris Schools, 445.
Patents in America, 336.
in Perth Dye Works, 357.
on Plymouth Pier, 74.
in Portugal, 289.
in Prague Gas Works, 313.
in Printing Works, Hanover, 217.
Private and Domestic, 74, 99, 101, 219.
in Queen's College, Belfast, 291.
at Rotterdam Port, 465.
in St. Louis Custom House, 25.
on Ships, 25, 49, 73, 75, 121, 149, 170, 193, 194, 218, 241, 242, 265, 448, 465, 466, 467, 469, 487, 525, 527, 529.
Spectacles for, 447.
in the Stock Exchange, 446.
at Suakim, 73.
in Sugar Factories, Havana, 545.
in Theatres, 49, 145, 146, 193, 217, 265, 382, 405, 427, 465, 526, 549.
in Towns Abroad, 49, 97, 98, 121, 145, 217, 242, 313, 333, 381, 405, 425, 427, 445, 446, 465, 485, 507, 545, 548.
in Towns at Home, 49, 425, 466, 488, 529, 545
on Trains, 292.
at Turin Exhibition, 505, 529, 545.
on Underground Railway at Naples, 405.
in Vienna Rath-haus, 241, 545.
for War Purposes, 243, 313, 381, 405.
Westminster Vestry and Board of Trade, 47.
at Wigan Coal Company's Works, 425.
the Wimbledon Trials, 148.
at Wycombe, 565.
Electric Lighting Act:—
The Dynamicables Committee, 486.
Mr. Offor on, 293.
Westminster Vestry and Board of Trade, 27.
Mr. A. White's Opinion, 269.
Electric Repeating Clock, 565.
Electric Sparks: How to Produce Long Ones, 148.
Electric Synchronism, 469.
Electricity:—
Among the Ancients, 361.
Brake Worked by, 566.
and Chemical Industry, 489.

NOTES (*continued*):
Electricity:—
v. Compressed Air, 383.
in the Lecture Room, 148.
as a Motive Power, 99.
for Nothing, 566.
Practical Applications of, 100.
Prospecting for Minerals by, 566.
its Relation to Vital Power, 29.
Electro-Dynamometer, Bellati's, 26.
Electro-Dynamometer, Lippmann's Mercurial, 488.
Electrolysis in Preparing Indigo Vats, 548.
Electrolysis of Cellulose, 548.
Electrolysis, Weill's Method of Coating Metals, 467.
Electro-Magnetism, Discoverers of, 465.
Electro-Musical Effects, 566.
Electro-Petroleo Motor, 547.
Electromotive Force, M. Chaperon on, 359.
Exhibitions:—
American, 193.
Antwerp, 147, 384, 405, 465, 485, 546, 547.
Boston, 145, 426.
Brussels, 1, 313.
Forestry, 28, 382.
Furniture, 26, 49.
Health, 4, 50, 196, 506.
Hygienic at Berlin, 98.
Inventions, 316, 507.
New Orleans, 170, 446, 526.
Paris, 405.
Philadelphia, 289, 334, 381, 405.
Rouen, 217.
Steyr, 289, 358.
Turin, 75, 98, 466, 505, 545.
Vienna, 266.
Close of Health, 566.
Extension of the Electric Light, 566.
Filter, Dobell's Electric, 426.
Fire Alarms in London, 50.
Fire at Albert Hall, 218.
Fire in the Swan Factory, 73.
Flames, Electric Properties of, 172.
Fogs, The Telephone and Navigation in, 384.
Frankland, E., Honours for, 49.
Franks' Granule Carbon Battery, 468.
French Academy of Sciences, Prizes Presented by, 27.
French Telegraph Revenue, 465.
Fresnel, Statue to, 121.
Frictional Machines and Moisture, 172.
F.S.V. Accumulators, Gadot's Improvements in, 290.
F.S.V. Accumulators, New Type, 26.
Fulham Provisional Order Granted, 121.
Gambling by Telegraph, 508.
Gas, Candle-Power of London, 290.
Gas Companies, Amalgamation of, 169.
Gas and Electric Lighting, 100, 268, 567.
Gas and Electricity in France, 147.
Gas Engine, Economy of, 145.
Gas Lighters, Electric, 28.
Gases, Electric Discharges in, 445.
Gaulard and Gibbs' System at Turin, 505, 529, 545.
Gérard Incandescent Lamp, 123.
Gilchrist Scholarship, award of, 145.
"Giralda, The," Struck by Lightning, 2.
Glass, Electrolysis of, 316.
Gold in Paris Streets, 98.
Gordon, General, an Attempt to Reach him, 333.
Gore, Dr. G., Unequal Resistance at Cathodes, 468
Gouraud, Col., Elected Chairman of Oriental Company, 25.
Gravesend Provisional Order, 313.
"Great Eastern, The," 73, 97.
Greece, Telegraphic Communication with, 333.
Greely Expedition, The, 334.
Greenwich Observatory Report, 101.
Gülcher Company, The, 526.
H. at Oxford, 74.
H. at Paris, 333.
Hail, Curious Movements of, 242.
Hammers, Magnetic, 546.
Hand, The, as a Telephonic Receiver, 28.
Harvest and Weather Reports, 50, 145, 193, 218.
Hastings Electric Light Company, 97.
Hedge's Cut Outs, 169.
Hemp Cables, Baker's Patent, 49.
Hochhausen Dynamo, Manufacture of, 25.

NOTES (*continued*):
Hochhausen System, The, 448.
Holmes, O. W., and the Early Days of Telegraphy, 446.
Honours for Electricians, 49, 217, 266.
Huxley, Professor, on Science Teaching, 4.
Ice, Resistance of, 358.
Incandescent Circuits, Arc Lamps on, 171.
Incandescent Lamps:—
Gérard's, 123.
Life of a 10 Candle-power, 124.
Roussy's Regulator for, 466.
v. Petroleum, 568.
Weston Mammoth, 547.
India Rubber, New Source of, 506.
India Rubber Company's Bill, 169, 193.
Indian and Oriental Company, Reduction of Capital, 218.
Indian Postal and Telegraph Service, 565.
Indigo Vats, Goppelsrœder's Electrolytic Experiments, 548.
Induction Lamp, Delaurier's, 505.
Induction on Wires, Gisborne's Experiments, 195.
Institute of Chemistry, 169.
Institute of Patent Agents, 51.
Insulation of Conductors, Malisz's Plan, 546.
Insulite Company, The, 566.
Inter-Colonial Telegrams, The Tariff Question, 27.
International Society of Electricians, 565.
Iridium, Electro-deposition of, 148.
Iron Cell, Benton's, 123.
Iron, Magnetic Polarity of, 122.
Iron, Maxwell-Lyte's Paint for, 195.
Iron and Steel Wires, Resistance of, Under Stress, 4.
Jamin, M., Elected Secretary of French Academy, 98.
Journals, Electrical, New, 26, 49.
Krupp Ironworks, 289, 405.
Laryngoscope, Dr. Seller's Electric, 122.
Launch, Electric, Banks's, 335.
Launch, Electric, on Windermere, 358.
Launches, Electric, Race between, 427, 448.
Legal:—
Central News *v.* Eastern Telegraph Company, 3.
Crompton *v.* Maxim-Weston Company, 26.
Gutch *v.* Post Office, 382.
Jablochkoff Company *v.* Proprietor Lyceum Theatre, Edinburgh, 97.
Saunders and Son *v.* United Telephone Company, 381.
United States Company *v.* Brush, 336.
Wandsworth Board *v.* United Telephone Company, 121.
Lifts, Electric, in America, 465.
Lighthouses, Electric Lighting for, 76, 121, 219, 290, 334, 381, 405, 429, 446, 466.
Lighthouses in France, 334, 381.
Lightning:—
Accidents from, 2, 25, 26, 49, 101, 122, 146, 169, 170, 197, 217, 220, 221, 241, 268, 289, 291, 313, 333, 406.
and Collieries, 5, 77, 335.
Effects of, 220.
Popular Fallacies as to, 505.
Lippmann's Mercurial Electro-Dynamometer, 488.
Liverpool Electric Supply Company, 25.
Lloyd's Signal Stations, 217.
London and Globe Telephone Company Bought up, 145.
Magnet, New Form of, 466.
Magnetic Observatory at Rome, 169.
Magnetic Polarity of Iron, 122.
Magnetic Records at Greenwich, 101.
Magnetism, Theory of, 315.
Magnetism of Organic Bodies, 221.
Magnets, Dynamo, Cardew's Method of Winding, 100, 487.
Magnets, Duter's, 315.
Manganese in Plants, 169.
Manganese Mines in Nova Scotia, 194.
Maxim Lamp in New York, 217.
Maxim-Weston Company, Reduction of Capital, 194.
Mediterranean Extension Company's Bill, 193.
Meridian Conference, The, 465, 485, 505, 527.
Metals, Weill's Method of Coating, 467.
Meteor, A, 289.
Meteorological Observatory at Falmouth, 313.
Meyer, H. B., Death of, 333.

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NOTES (*continued*):
Microphone, Curious Experiment with, 28.
Microphone, Vandenberghe's Improvements, 505.
Military Telegraphy, 2.
Miner's Safety Lamp, 289.
Mines, First Attempts to Light, 26.
Moigno, Abbé, Death of, 219, 244.
Money Orders in India, Telegraphic, 266.
Money Orders, International Telegraphic, 98.
Morse Instrument, The First, 507.
Muirhead's Duplex System, 146.
Music by Telephone, 408, 428.
Nantucket Cable, The, 267.
New Lightning Conductor, 567.
New Orleans Exhibition, 170.
News for Clubs, 122.
Normann, Baron, Honours for, 1.
Oil Tanks, Protection from Lightning for, 219.
Oilworks Struck by Lightning, 49.
Olden Times, 446.
Organic Bodies, Magnetism of, 221.
Oriental Telephone Company, 565.
Orkney, Telegraphic Extension in, 194.
Painting Iron, Maxwell-Lyte's System, 195.
Panics and the Telegraph, 508.
Paper Counter and Register, Electric, 23.
Paris Fire Brigade, 145.
Paris, Gold in Streets of, 98.
Paris, Hotel de Ville, Electric Motors at, 503.
Paris Magnetic Observatory, 407, 446.
Paris Underground Railway, 508, 523.
Parod's New Accumulator, 505.
Patent Agents, Institute of, 51.
Patent Fees, Reduction of, 266.
Patents Convention, International, 169.
Patents Taken Out in 1883, 382.
Pekin, Telegraphic Extension to, 357.
Peltier Effect, 29.
Pender, J., M.P., Presented with Freedom of Wick, 357.
Pender Gold Medal, Award of, 546.
Peroxide of Lead Cells, 243, 314.
Petroleum Motor, a, 547.
Philadelphia, Electrical Conference at, 121.
Photometric Standard, Gas Institute's Report, 124.
Photometric Standard, Violle's, 51, 147, 219.
Platinum in Russia, 547.
Porter, Rufus, Death of, 425.
Post Office, Extension of, 525.
Post Office, General, Additions to, 99.
Post Office Protection Act, 335.
Post Office and the Telephone, 1, 100, 124, 146, 170, 243, 266, 267, 382, 383, 545.
Post Office, The, and the Telephone Companies, 568.
Post Offices, Sunday Work in, 170.
Post Office Volunteers, 51, 466, 485.
Postal Telegraphs, Appointment at Nottingham, 314
Postal Telegraphs, Candidates for Vacancies, 145.
Postel-Vinay, M., Legion of Honour for, 217.
Power, Transmission of, 26, 98, 265, 547.
Preece, W. H., Appointed Visitor to Cooper's Hill, 265.
Press Messages on Military Lines, 3.
Printing by Electricity, 335.
Private House Lighting, 565.
Provincial Brush Co., Reduction of Capital, 314.
Provisional Orders, 25, 49, 97, 121, 145, 169, 193, 218, 268, 291, 313, 361.
Quick Work, 145, 447.
Quicksilver Mines, 146.
Railway Crossings, Electric Gateopeners for, 218, 357.
Railway Signals, Electric, Accident Prevented by, 218.
Railway, Underground, for Paris, 503, 523.
Railways, Electric:—
in America, 265.
at Blackpool, 546.
at Brighton, 52, 314, 437.
in Brussels, 405, 486.
at Chillon, 507.
at Cleveland, 313, 334, 359.
the Daft, 336.
at Edinburgh, 382, 547.
at Frankfort, 547.
Holroyd Smith's at Manchester, 332.
the Lartigue, 317.
in Switzerland, 74.

NOTES (*continued*):
Railways, Electric:—
at Zankeroda Mines, 385.
Railways, Electricity and, 2.
Rain to Order, 242.
Ransome's Converted into Limited Company, 1.
Rapid Telegraphy, 447.
Regulator, Bellati's Automatic, 425.
Regulator for Incandescent Lamps, Roussy's, 466.
Reiss's Telephone, 242.
Removals: 25, 49, 97, 145, 217, 313, 425, 465 (*see* also BUSINESS NOTICES).
Resignations:—
Beeman, J. S., South Eastern Brush Company, 169.
Capito, C. H., Electrical Power Storage Company, 169.
Harold, H. Z., of Johnson and Phillips, 217.
Lodge, Professor, Physics Chair, City and Guilds Institute, 50.
Phillips, F. C., Hammond Company, 1.
Resistance at Cathodes, Gore's Experiments, 468.
"Retriever," Stranding of, 26.
Reynier's Zinc-Lead Battery, 2, 449.
Rings, Electro-Chemical and Thermic, 446.
River Plate and Consolidated Telephone Companies, 50.
Roscoe, Professor, Knighted, 193.
Roussy's Regulator for Incandescent Lamps, 466.
Royal Academy, 146.
Royal Society, New Fellows, 121.
Royal Society's Conversazione, 98.
Rysselberghe System in Belgium, 360, 425, 428, 526.
Rysselberghe Telephone System in France, 193.
Sabine, T. R., Death of, 97.
Safety Lamp, Morgan's, 289.
Safety Lamps in Paris, 98.
Safety Lamps for Vienna Firemen, 313.
Science Teaching, Professor Huxley on, 4.
Scotland, Telegraphic Communication in the North of, Lloyd's and the Post Office, 528.
Scotland, Telegraphic Extension in, 265, 503.
Scudamore, F. I., Will of, 381.
Seismograph, Multiplying, 266.
Sewer Struck by Lightning, 122.
Sewing Machines and Electricity, 425.
Ship Lighting, 569.
Siam, The Telegraph in, 241.
Siemens, The Late Sir W., 265.
Siemens Small Arc Lamps, 122, 525.
Signalling between London and Portsmouth, 359.
Signals for Telephonic Communication, 569.
Silver, Electro-chemical Equivalent of, 242.
Sims' Mechanical Telephone, 445.
Society of Arts, award of medals, 146.
Society of Telegraph Engineers, 565.
Solar Induction, 568.
Soudan, The Telegraph in, 73.
South Australia, Rules for Cipher Messages, 546.
South Eastern Brush Company, Reduction of Capital, 239.
Spain, Duplicate Cable to, 1.
Spanish National Company's Head Office, 49.
Spectacles for the Electric Light, 447.
Spectra of the Arc, 315.
Spectra of Silicon Fluoride, 143.
Spottiswoode Memorial, The, 217.
Stayton, J. H., Testimonial to, 545.
Steno-Telegraphy, 194, 546.
Stock Exchange Panics and the Telegraph, 508.
Storms, Telegraphic Warnings of, 50, 145, 193, 218.
Strasburg Tree of Liberty, 241.
Submarine Exploration, 194, 445.
Sulphate of Copper Solutions, Macgregor's Experiments, 195.
Sun, The Temperature of, 217.
Sunda Straits Disaster, 146.
Sunday Work in Post Offices, 170.
Sunspots, Greenwich Records, 101.
Swan Factory, Fire in, 73.
Swan Works at Newcastle, 221.
Swimming Competition, 446.
Synchronism, Electric, Deprez's Apparatus, 469.
Synchronisation, Telephonic, 508.

NOTES (*continued*):
Telegrams in Australia, The Tariff Question, 27, 97, 121, 546.
Telegrams and their Use, 194.
Telegrams, Sixpenny, 358, 505, 545.
Telegraph Clerk Taken Prisoner, 25.
Telegraph Clerks' Conference, 99, 172.
Telegraph Clerks' Grievances, 486, 525.
Telegraph Conference, The Approaching, 488, 507, 509.
Telegraph Instruments in France, 313.
Telegraph in Ironworks, 289.
Telegraph and Panics, 508.
Telegraph Poles and Wire in Brooklyn, 49.
Telegraph Revenue, Postal, 465.
Telegraph, Wilkins's, 219.
Telegraph Wires, Tapping, 292.
Telegraphic Communication, Lloyd's and the Post Office, 528.
Telegraphic Instrument, The First, 507.
Telegraphic Money Orders in India, 266.
Telegraphic Money Orders, International, 98.
Telegraphing Communication without Wires, 567.
Telegraphing Shorthand, 194, 546.
Telegraphists, Massacre of at Berber, 1.
Telegraphs in the British Empire, 426.
Telegraphy, Early Days of, 446.
Telegraphy in the Field, 2.
Telegraphy, Fast Speed, 26.
Telegraphy, Rapid, 145, 447.
Telegraphy, Remarkable Feat in, 194.
Telephone:—
and the Aasgeier in Brazil, 99.
in Aberdeen, 315, 426.
in America, 26.
in Antwerp, 488.
in Belgium, 360, 425, 423, 436, 526, 545.
in Brazil, 123.
at Brussels Law Courts, 385.
Chess Played by, 466.
and Cholera, 547.
and Communication with Clubs, 171.
on the Continent, 447.
Curious Experiment, 28.
in Dundee, 406.
and Dynamiters, 74.
in Edinburgh, 245.
in England and America, 51.
in Europe, 506.
Exchange Licences, 52.
Experiments between London and Dover, 467.
Experiments at Rome, 290.
in France, 172, 265, 405, 446, 447, 486.
in Germany, 25.
and Gunnery, 487.
in Holland, 121.
Irish's Automatic Recorder, 357.
in Italy, 506, 546.
in Jamaica, 97.
in Leeds, 445.
The London and Globe Shares, 485.
and Machinery Breakdowns, 74.
Measuring Distant Temperatures by, 548.
in Mines, 193.
in Mons, 384.
in Monte Video, 485.
and Navigation in Fogs, 384.
New York and New Jersey Company, 506.
Orders for Consolidated Company, 525.
in Plymouth, 243, 547.
Poles and Wire in Brooklyn, 49.
Post Office and the Companies, 1, 100, 124, 146, 170, 243, 266, 382, 383, 545.
in the Potteries, 467.
in Providence, 97.
in Russian Fortresses, 1.
Rysselberghe's system in Belgium, 360, 425, 428, 526, 545.
Rysselberghe's System in France, 193.
in the Scilly Islands, 25.
in Servia and Turkey, 266.
at Sheerness Dockyard, 485.
on Shipboard, 525.
Sims' Mechanical, 445.
in Spain, 428.
in Sunderland and Newcastle, 2.
Transmission of Music by, 408, 423.
Trials between St. Petersburg and Bologoe, 358.
in the West Indies, 122, 406.
Telephone Company of Ireland, Issue of Shares, 193.

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NOTES (*continued*):
Telephonic Synchronisation, 508.
Telethermometer at Brussels Theatre, 407.
Testing Apparatus, Blackburn's, 486.
Thermo-Electric Battery, Riatti's, 546.
Thomson, Sir W., Honours for, 49.
Toledo Electric Company, 527.
Torpedo Boat, New, 217.
Torpedo Boat, Tuck's Electric, 360.
Torpedo Service, The, 267.
Torpedoes and the Franco-Chinese War, 525, 545.
Trabue, G. W., Death of, 25.
Train Lighting, 292, 314.
Trains, Communication on, 170, 506.
Trouvé's Lamp, 505.
Tuning Fork, Recording Vibrations of, 243.
Turks, The, and the Telegraph, 243.
Units, M. Hospitalier on, 505.
Vienna Stadttheater Fire, 122.
Voltameters, Guillaume's Experiments, 241.
Volunteers, Postal Telegraph Corps, 51, 466, 485.
Watch, Non-Magnetisable, 406.
Waterspout, A, 358.
Watts, Henry, Death of, 170.
Weather Reports and Harvest, 50, 145, 193, 218.
Weaving by Means of Electricity, 196.
Weill's Method of Coating Metals, 467.
Western Electric Company, 76, 97.
Westminster Vestry and Board of Trade, 27.
Weston Mammoth Lamp, The, 547.
Whale Caught by a Cable, 316.
Wilkins's Telegraph, 219.
Wimbledon Winners, 265.
Winch, Electric, 358.
Wires:—
Stress and the Resistance of, 4.
He Forgot to Put them in, 4.
Wires, Overhead:—
in Chicago, 28.
in London, 245, 267, 314, 381, 527.
in New York, 28, 289, 525.
and Private Property, Mrs. Gutch *v.* Post Office, 382.
Protection Afforded by, 447.
Professor S. P. Thompson on, 195.
in Wandsworth, 121, 169, 289.
Wires, Underground:—
in Chicago, 25, 98, 145, 333, 505.
in Edinburgh, 487.
The Howe System, 218.
in New York, 49, 169, 195, 317, 445.
in Philadelphia, 525.
Wrong Order, The, 407.
Zinc Accumulator, New, 2, 449.
Zinc, Amalgamated, E.M.F. of, 449.

Nystrom, J. W., Electro-dynamics, 258.

O

Oredresser, Electro-magnetic, 326.

P

Paris Electrical Congresses, 69.
Patent Rights, International, 514.
Patents for Regulating Currents, by C. A. Stephenson, 225.
Photometrical Standards, by Professor Bruce Warren, 104.
Pilsen, Co.'s, Exhibits at Health Exhibition, 556.
Planté, G., Globe Lightning, 366.
Porte-Manville Electric Governor, The, 367.
Postmaster-General's Annual Report, 275.
Postmaster-General *v.* Cambrian Railways, 330.
Postmaster-General *v.* Wandsworth Board, 43.
Post Office and the Telephone Companies, 84, 132, 322, 328, 378 (*see* also NOTES).
Potential, Electrostatic Standard of, 296.
Power, Electrical Transmission of, 530.
Power, Electrical Transmission of in Mines, 551.
Practical Joke, A Telegrapher's, 372.
Preece, W. H., The Paris Electrical Congresses, 69.
Preece, W. H., Use of Secondary Batteries in Telegraphy, 498.
Preece, W. H., The Watt and Horse-Power, 473.
Probert, I., Primary Batteries for Electric Lighting, 161, 183.
Pulvermacher, J. L., Death of, 435.

R

Railways, Electricity as a Motive Power on, 552.
Railway Signalling, Use of Electro-Magnets for, 577.
Rayleigh, Lord, Address to British Association at Montreal, 373.
Resistances, Small, Bridge for Measuring, by E. C. Rimington, 89.

REVIEWS:—
Fahie, J. J., History of Electric Telegraphy, 18.
Gordon, J. E. H., Electric Lighting, 32.
Haden, Dr. E., "Die Elektrische Beleuchtung," &c., 570.
Higgins, C., Treatise on the Law of Patents, 18.
Hunt, G. B., Handbook to Patents Act, 18.
Kempe, H. R., Handbook of Electrical Testing, 343.
May, G., Bibliography of Electricity, 18.
Munro, J., and Jamieson, A., Pocket Book of Electrical Rules, 35.
Preece, W. H., and Sivewright, J., Telegraphy, 343.
Sprague, J. T., Electricity, 35, 92.
Thompson, Professor S. P., Dynamo-Electric Machinery, 416.
Wigan, Gordon, "The Electrician's Pocket Book," 499.

Richardson's Electric Governor, 226.
"Richelieu," The, Electric Lighting on, 450.
Rimington, E. C., Bridge for Measuring Small Resistances, 89.
Rimington, E. C., Electric Light Engineering (*see* CRAWLEY).
Roscoe, Sir H., Address to Section B, British Association, 400.
Roussy's Electric Light Moderator, 542.
Rowland, Professor, Address to Philadelphia Congress, 481, 500.
Rowland, Professor, Theory of the Dynamo, 516, 535.
Rysselberghe Telephone System in Belgium, 560.

S

Schuckert Dynamo, The, 304.
Schulz, W. S., Power Transmission in Mines, 551.
Schuster, Professor, Passage of Electricity Through Gases, 212.
Screws, B. A. Committee's Report on, 417.
Share List, 24, 48, 72, 96, 120, 144, 168, 192, 216, 240, 264, 288, 312, 332, 356, 380, 404, 424, 444, 464, 484, 524, 544, 564.
Ships Lights, Regulations for, 352.
Siemens' Apparatus for Testing Lightning Rods, 369.
Siemens' Dynamometer, 318.
Siemens' Dynamos, 323, 352.
Siemens' Exhibits at Health Exhibition, 346.
Siemens, Sir W., Proposed Memorial to, 179.
Silver, Electrolysis of Fluoride, &c., of, by Dr. Gore, 341.
Smith, Willoughby, Induction, 138.
Smith's Ergometer, 9, 79.

SOCIETIES' MEETINGS, &c.:—
Arts:—
Professor F. Jenkin on Telpherage, 41, 66.
Probert I., Primary Batteries for Electric Lighting, 161, 183.
Webber, Colonel, on Telegraph Tariffs, 163.
Telegraph Engineers:—
Professor Forbes on Conductors and Heating, 16, 39, 63, 82.
Mance, H. C., on Cable Testing, 21.
Preece, W. H., on Paris Congresses, 69.
Blakesley, T. H., Current and Conductors, 106.

Sounding Apparatus, by Admiral D. Ammen, 457.
South Eastern Brush Company, *re*, 330.
Sprague, F. J., Report on Dynamos Exhibited at Crystal Palace, 231, 259, 280, 304, 323, 351.
Sprague, J. T., Electricity and Light, 7, 81, 135, 224.
Spring, New Form of, for Meters, by Professors Ayrton and Perry, 85, 109.
Steam Engines (*see* ENGINES).
Stephenson, C. A., Patents for Regulating Currents, 225.
Stone, Dr., and Dangerous Currents, 108.
Sturgeon, William, His Life and Work, 186.
Sulphuric Acid, Electrolysis of in Accumulators, 234.
Swan-Brush Secondary Battery Patents, 95.
Sweetness and Light (Leading Article), 572.
Switches, Consolidated Electric Company's, 119.
Synchronous-Multiplex-Telegraphy, 410.

T

Tait, Professor, Thunderstorms, 114, 128.
Telegrams, Deferred (Leading Article), 60.
Telegraph, The, and Colonial Federation, 300.
Telegraph Engineers' Society (*see* SOCIETIES).
Telegraph, The, and Imperial Defences, 554.
Telegraph Tariffs, by Colonel Webber, 163.
Telegrapher's Practical Joke, A, 372.
Telegraphs, Ancient, 561.
Telegraphs and New Agencies (Leading Article), 12.
Telegraphy, Synchronous-Multiplex, 410.
Telephone Companies and the Post Office, 84, 132, 328, 328, 378 (*see* also NOTES).
Telephone Case, The Drawbaugh, 511.
Telephone Signal, Cary's, 512.
Telephone Transmitter, Moseley's, 136.
Telephony, Long Distance, in Belgium, 560.
Telephony in South Australia, 402.
Telpherage, by Professor F. Jenkin, 41, 66.
Terni, Electric Light at, 250, 279.
Test, A Galvanometer and Battery, 247.
Testing Apparatus, Woodbury's 209.
Testing Establishment, Howard's, 295.
Thompson, Professor S. P., Standard Tangent Galvanometer, 478.
Thomson, Sir W., Address to Section A, British Association, 397.
Thomson, Sir W., Gyrostatic Model of the Compass, 492.
Thunderstorms, by Professor Tait, 114, 128.
Thunderstorms (*see* also LIGHTNING).
Timmis, I. A., Use of Electro-Magnets for Railway Signalling, 577.
Tomlinson, H., Hall's Phenomenon, 63.
Torpedo Boat, Williams's, 518.
Tramcars worked by Accumulators in Brussels, 94.
Trees and Lightning, 397.
Trinity House Experiments at South Foreland 349.
Trotter, A. P., Artificial Light Tables, 38.
Trotter's Dynamometer, 202.
Trouvé's Electric Jewellery, 250.
Tuning Fork, Determining the Period of, 297.

V

Varley's Electric Governor, 227.
Voice, E. L., Electricity as a Natural Force, 531
Volckmar, Ernest, Death of, 258.
Voltmeter, New, by Captain Cardew, 431.
Voltmeter, Solenoid, by Professor J. Blyth, 432.

W

Waltenhofen, Von, Field Magnets of Dynamos, 38.
Warren, Professor Bruce, Photometrical Standards, 104.
Watt, The, and Horse-power, by W. H. Preece, 473.
Webb, F. C., Old Cable Stories, 55, 203, 272, 365, 415, 436, 510.
Webber, Colonel, Telegraph Tariffs, 163.
Weston Dynamos, 324.
Williams' System of Coast Defence, 518.
Wires, Overhead:—
Bristol Corporation *v.* United Telephone Company, 192.
in New South Wales, 416.
Postmaster-General *v.* Cambrian Railways, 330.
Wandsworth Board *v.* Postmaster-General, 43.
Wandsworth Board *v.* United Company, 22.
See also NOTES.
Woodbury's Testing Apparatus, 209.
Woodhouse and Rawson's Exhibits at Health Exhibition, 412.

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THE ELECTRICIAN:

A WEEKLY JOURNAL OF

THEORETICAL AND APPLIED ELECTRICITY AND CHEMICAL PHYSICS.

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NOTES.

The West Indies.—Telegraphic communication between Key West and Havana is interrupted.

Telegrams for the West Indies.—Telegraphic communication between Key West and Havana is interrupted.

Central News v. Eastern Telegraph and Others.—The further hearing of this case will be taken next Saturday.

Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended 2nd instant amounted to £3,797.

Brussels.—It is proposed to hold an international exhibition in 1887. Electricity is expected to hold an important place in this exhibition.

Telpherage.—Professor Fleeming Jenkin's paper on this subject was read on Wednesday at the Society of Arts. The paper will be given in our next issue.

A New Atlantic Cable.—A Reuter's telegram from Halifax states that the "Faraday" had successfully laid the shore end of the new Atlantic cable on Friday last week.

Lundy Island.—Telegraphic communication has been extended from the Postal Telegraphic Office at Hartland to a new signal station established by Lloyds on Lundy Island.

Egypt.—Telegraphic communication between Korosko and Abou Hamed was destroyed on Monday last. Debbeh is now the last station to which telegraphic communication extends.

Personal.—We understand that Mr. F. C. Phillips has left the Hammond Company as their managing electrician, and intends practising as an electrical and consulting engineer.

Society of Telegraph Engineers.—At the next meeting of the Society of Telegraph Engineers and Electricians, May 22, Mr. Preece is going to give a paper on the results of the three electrical congresses of Paris.

Philadelphia.—It is reported that all the available space in the Philadelphia Electrical Exhibition building has been applied for, and that the question of building one or more annexes is now under consideration.

Western and Brazilian Telegraph Company.—The traffic receipts for this company for the week ended 9th inst. were £2,916, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

Direct Spanish Cable.—The duplicate cable of this company between Kennack Cove, Cornwall, and Bilbao, Spain, has been successfully laid, and is in perfect working order. The cable was manufactured and laid by the Telegraph Construction and Maintenance Company.

Telephones in Russian Fortresses.—The St. Petersburg *Novoe Vremya* of 10th instant states that the War Department has successfully completed an experiment with telephones at the Sweaborg forts, and proposes the adoption of this means of communication in fortresses generally.

Great Northern Telegraph Company.—This company's bankers, Messrs. C. J. Hambro and Son, No. 70, Old Broad-street, E.C., are now prepared to issue new share certificates, with fresh coupon sheets, in exchange for the old certificates, which are to be given up with the talon attached.

Personal.—His Majesty King George of the Hellenes has been graciously pleased to confer upon Baron John de Normann, Superintendent of the Mediterranean Extension Telegraph Company at Corfu for the last 20 years, the Gold Cross of Knighthood of the Most Noble Order of the Saviour, as a mark of his sovereign approval.

Lundy Island.—Telegraphic communication has been extended from the Postal Telegraph Office at Hartland to a new signal station established by Lloyd's on Lundy Island. The fee charged by Lloyd's for signalling telegrams to and from passing vessels, or for reporting vessels, is 3s. 6d. if the message or report does not exceed twenty words, additional words being charged for at the rate of 6d. for five words or fraction of five words.

Ransomes, Sims, and Jefferies.—This old and well-known firm has on account of the continuous extension of business, and the desirability of fixing the capital employed in it, been converted into a private limited company, constituted under the Companies Acts, 1862 to 1883, and has been registered, and will be henceforward carried on under the name of Ransomes, Sims, and Jefferies (Limited). The new company has acquired all the assets, and will discharge all the liabilities of the partnership. The management of the business of the company will be continued by the partners of the late firm.

Reported Massacre of Berber Telegraphists.—The Cairo correspondent of the *Daily News* stated on Tuesday last that the sub-inspector of the telegraph had escaped from Berber to Korosko, but his colleagues remained at Berber waiting for camels, and owing to the absence of telegraphic communication they received no instructions, were captured, and, it is said, massacred, while endeavouring to reach Abou Hamed, by the rebels, by order of the Emirs of the Mahdi.

The Post Office and the Telephone Companies.—In reply to Mr. Sexton, Mr. Fawcett stated in the House of

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Commons last week that no royalty had ever been demanded from the telephone companies for payments made to them for advertisements in their own catalogues. There was a royalty demanded for a certain payment of one guinea made by some subscribers in addition to their ordinary rent, but the nature of this payment being explained the demand was at once withdrawn.

FIELD TELEGRAPHING.—Under instructions from army headquarters a committee has been ordered to assemble at Alder shot and report on the value of the various methods of effecting telegraphic communication between outposts and the main body in the field. The committee is constituted as follows:—President: Major-General Lyons, C.B. Members: Lieut.-Colonel Hale (1st Battalion Scottish Rifles), Lieut.-Colonel Hanning Lee (2nd Dragoon Guards), and Lieut.-Colonel Hamilton, R.E.

EARTH CURRENTS.—We have received from M. E. Blavier a pamphlet containing the results of his investigations upon earth currents. This work is entitled "Etude des Courants Telluriques," par E. E. Blavier, Inspecteur-Général au Ministère des Postes et Télégraphes, Directeur de l'Ecole Supérieure de Télégraphie, nd is published par ordre de M. le Ministre des Postes et des Télégraphes. The work contains a beautiful series of illustrations of curves obtained during the investigations.

TELEPHONY IN THE NORTH.—Telephonic communication is now established between Sunderland, South Shields, and Newcastle, under the auspices of the Northern District Telephone Company, who have arranged with the Postmaster-General for a trunk line. The yearly subscription for the use of the trunk wire between Sunderland and Newcastle by exchange subscribers is £6 10s.; and for that between Sunderland and South Shields £6. The annual charge for the use of the trunk wire from Newcastle to North Shields is £6.

ELECTRIC LIGHTING AT NOTTINGHAM.—The ground-floor room of the Central Free Library has now been lighted by 72 20-candle Swan lamps, the current being supplied from a Ferranti machine driven by the engine belonging to the Technical Schools. The lights are perfectly steady, and during one evening, though the library was crowded, the temperature rose only 2° F. The lamps are 41-volt lamps arranged three in series, the E.M.F. at the ends of the cables being 123 volts. The whole of the installation has been carried out by the staff of the physical department of the college.

THE GIRALDA AT SEVILLE.—A letter from Seville, says *The Times*, reports that a terrible thunderstorm, which occurred on the 25th of April, did serious mischief to the Cathedral and its famous campanile, known as "the Giralda." Great injury has been done to the picture, of considerable artistic value, over the southern entrance of the cathedral, the so-called "Puerta de los Palos," representing St. Sebastian before the Emperor Diocletian. It is reported that as soon as Queen Isabella heard of the accident she telegraphed that she would defray the expenses of erecting conductors out of her private purse.

THUNDERSTORM.—About half-past four o'clock on Monday afternoon a storm, accompanied by loud and prolonged peals of thunder and vivid flashes of lightning, passed over London, doing considerable damage to property in the West. No. 141, Westbourne-terrace, Paddington, a large dwelling-house at the corner of Westbourne-terrace and Bishop's-road, was struck by lightning, causing a chimney, ten feet high by eight feet wide, to fall with a loud crash into the footpath beneath, but fortunately not injuring anybody. The roof of 28, Bishop's-road also was destroyed, but the only person on the premises was the caretaker, who was not injured. The goods in the house were severely damaged by the falling *débris*.

NEW BOOKS.—The long-promised work of Mr. J. E. H. Gordon on electric lighting has been issued. It is published by Messrs. Sampson Low and Co., the exact title being "A Practical Treatise on Electric Lighting." It is well illustrated and carefully printed, as might, indeed, be expected of any book issued by this firm. Our notice of the text must be left to another date, except, perhaps, to say that in many respects it inaugurates a new departure. The electrical principles upon which this particular application of electricity is founded are first discussed. Then we come to chapters on incandescent lamps, on arc lamps, on dynamos, on storage, photometry, meters, and so on, concluding with a series of useful tables.

SECONDARY BATTERIES.—*L'Electricien* contains an article by M. Emile Reynier on a zinc accumulator which appears to be a secondary battery, with an anode (in charging) of lead and a cathode of zinc. The ratio of stored energy to weight in the case of several batteries, inclusive of the above, is given by the author as follows:—

	Kilogrammètres.
1 kilogram of the Planté accumulator, small size, "formed" by the inventor, stores	1,500
1 kilogram of the Faure accumulator, old form, weighing 8 kilograms, stores...............	3,000
1 kilogram of the Faure accumulator, more recent form, weighing 30 kilograms stores	4,400
1 kilogram of the present zinc accumulator of the form, weighing 17 kilograms stores...............	7,600

We are not, however, informed how the zinc, when once dissolved, can be reduced by the charging current without a ruinous waste of energy expended in the evolution of hydrogen gas.

COST OF THE ELECTRIC LIGHT IN NEW YORK.—"The following contracts for electric lighting," says the American *Electrical Review* of May 3, "in this city were awarded on the 17th inst for ensuing year:—The United States Electric Illuminating Company was awarded a contract at seventy cents per night for each lamp for lighting Battery Park, City Hall Park, Washington-square, Tompkin-square; Broadway, from Battery-place to Twelfth-street; Fifth-avenue, from Washington-square to Thirteenth-square; Bleecker-street, from Broadway to Eighth-avenue; South-street, from Whitehall to Grand; Eighth-avenue, from Bleecker to Fourteenth-street; Gansevoort Market-square; East Broadway, from Chatham-square to Grand-street; and West-street, from Battery-place to West Eleventh-street. The Brush Electric Light Company was given the contract at the above-named price for electric lights in the following territory: Fourteenth, Twenty-third and Forty-second-streets, from the East River to the Hudson; Fifty-third-street, from Third to Ninth-avenue; Seventh-avenue, from Fourteenth to Fifty-ninth-street; Broadway and Fifth-avenue, from Fourteenth to Fifty-ninth-street; Fourth-avenue, from Eighteenth to Forty-second-street, and Union and Madison-squares.

ELECTRICITY AND RAILWAYS.—In the current number of the *Railway Engineer* the question of the application of electricity to railway purposes is commenced, and it seems that electricity is to play a prominent part in the railway work of the future, for the writer says, "Through all this cloud of doubt and beyond all these obstacles we plainly see in elec-

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tricity the vital principle of railway work in the future. Not only large stations will be lighted, but all signal lamps, signal boxes, and small stations throughout the line. The head and tail lights of trains, and all the carriages will be illuminated with the cool, soft, pure, beautiful light; the sickly glare and horrible odour of bad gas and rank oil will be barbarisms of the past; from end to end of every train perfectly easy and reliable communication between guard, passengers, and driver will be maintained by the electric current; electricity will apply the brakes; the driver and guard will at all times know the exact state of the line a thousand yards in front or rear; the power will be converted into heat for the purpose of warming the carriages; and just as the world will be growing alarmed at the approaching exhaustion of our coal beds, electricity, conveying mechanical work from the tidal waves, will take the place of our grand old locomotive, and draw the heaviest trains at a higher speed and under conditions of greater safety than the fastest and best equipped express of to-day."

Press Messages on Military Lines.—It is somewhat strange that the statements in a letter from "Cush" to the *Daily News* are published in face of Colonel Webber's evidence at the trial. "Cush" writes:—"The Lord Chief Justice said or implied that press messages were sent over that wire free of charge, and if they, the military, obliged the press in that way they had a right to see what was received. On the contrary, however, a through charge of 2s. 6d. per word was made by the military from Kassassin to England, at which rate I sent several messages myself. The rates, I think I am right in saying, were:—Alexandria to London 1s. 7d. per word, Alexandria to Ismailia 6d. per word, and Ismailia to Kassassin 5d. per word. So, after all, the military were not quite so obliging as they appeared to be, as they only charged 8s. 4d. for 20 words 20 miles, which in England would be sent for 1s. Considering this charge, surely Sir Charles Wilson had no right to read, or, if he had to read, surely not to divulge the Burleigh message. By making this known I think it will do something towards helping the Central News to win the point of law now under consideration, and thus have a verdict in their favour, which they so justly deserve." The only statement here to be considered is that about the charge from "Kassassin to Ismailia," or rather we should say want of statement, for there is not one word of proof that a charge was made on the military line. All other lines except this were lines erected, we should imagine, as ordinary business lines, and belonged either to the Egyptian Government or to the Eastern Telegraph Company, over which of course a charge was made. At Ismailia at the Egyptian office charges would naturally be made. At Kassassin Col. Webber said nothing was paid, and this more than once.

Brush Electric Light and Power Company of Scotland.—This company, acting under their directors' advice, and with unanimous consent of shareholders, went into voluntary liquidation on October 16th, 1883. Their share capital consisted of 22,000 shares of £5 each, with £2 10s. paid, and 8,000 shares of £5 each fully paid, their cash in hand being about £30,000, as against sundry liabilities. Three of the directors were appointed liquidators. Many intricate questions arose, for it seems by law that in a liquidation where two classes of shares exist, as above indicated, the fully paid shareholders can insist that the liquidator shall first call up the balance remaining upon the partially paid shares, so as to put all on the same level, and then divide equally. This of course would have acted disastrously upon the 22,000 shareholders, and a splendid opening for the lawyers seemed imminent. By tact, management, and mutual forbearance on each side the liquidators succeeded in settling all disputes, in keeping the company out of court, and reducing its law expenses incident to the liquidation to a sum under £200, and this with many threatening actions where contracts had to be compromised, and sales of going installations effected where under contract for years. The negotiations for a surrender of the license to the Anglo-American Brush Corporation was effected (without legal expenditure) by the liquidators themselves, and thirty-eight days from the passing of the resolution to wind up a dividend of 10s. and 20s. per share was returned, followed at an interval of two months by a further 5s. 10d. and 11s. 8d. per share, and within seven months the shareholders were called to the final meeting when the full accounts were placed before them, the fourth and last dividend making nearly 20s. per £2 10s. share agreed, and the company dissolved.

Central News v. Eastern Telegraph Company.—With reference to this case Mr. J. F. Andrews, editor of the Exchange Telegraph Company, writes to the *Daily News*:—"I have today read your comments upon the trial which terminated on Wednesday, and to which the Exchange Telegraph Company was a party. In the course of them you remark, 'Now the Exchange Telegraph Company, of which Sir James Anderson was the chairman, had no correspondent in Egypt.' A similar statement was made by the counsel for the plaintiffs, but the evidence not only of the defendants' witnesses, but that of the plaintiffs, showed that this company was represented by Mr. Tait, who followed the army under Sir Garnet Wolseley, and was sent out from London for that purpose, and by Mr. Atkins at Alexandria. Our payments to the Eastern Telegraph Company are ample proof of the activity of our representatives during the whole time of the Egyptian crisis in 1882. During that period our telegrams were appearing daily in the newspapers; if, therefore, such a statement, made by an independent and impartial journal, were allowed to pass uncontradicted, the inference that might be drawn would probably be more prejudicial to the interests of this company than any charges emanating from a rival agency. On the day of the battle of Tel-el-Kebir Mr. Tait was at Ismailia, and his telegram was produced in court as a commentary upon the charge against the Eastern Telegraph Company of 'expediting Diocles.' The telegram to Diocles left the Egyptian Telegraph office 38 minutes after the Burleigh telegram, but was not delivered in London until five or six hours after it. I am not giving you my own knowledge, but facts proved by witnesses in court. As your misapprehension of them has been stated in your columns, I hope your pages will be open to a correction."

Property in Cablegrams.—In the House of Commons, on Tuesday last, Mr. T. P. O'Connor (for Mr. Labouchere) asked the Postmaster-General whether it was his intention to take any action with a view to make the milking of cablegrams to this country by the officials of cable companies illegal; and to ensure, so far as is possible, the secrecy of all cablegrams sent to and from this country over land lines belonging to the Post Office.—Mr. Fawcett replied: Although the public is sufficiently protected by the existing law against messages passing over wires belonging to the Post Office being divulged, I fully admit the importance of, if possible, providing similar protection to foreign telegrams passing over the wires worked by private companies. The question is not free from difficulty, but I should be very glad to consider whether a clause could not be framed to be inserted in the Post Office Protection Bill to meet such a case as that referred to by my hon. friend. It has been intimated by some of the most important cable companies that they would be glad to see such a clause passed by the House. The Post Office Protection Bill, which now stands

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for second reading, is at the present time blocked, and this being the case, I am prevented until a second reading is obtained from putting on the paper any new clause that it may be intended to move in committee to carry out the object desired.—Mr. T. P. O'Connor asked whether the Postmaster-General would have any objection to consider the advisability of introducing into the proposed clause a provision which should ensure that no precedence should be given to the cablegrams of directors of cable companies.—Mr. Fawcett: If I can only get the second reading of this Bill, which is a purely administrative Bill, passed I shall put at once on the paper the form of clause, and shall then be glad to receive any suggestion.

Influence of Stress on the Electrical Resistance of Iron and Steel Wires.—In the *Proceedings* of the Manchester Philosophical Society, Mr. W. H. Johnson, B.Sc., describes some experiments made by him as follows:—A piece of piano steel wire, about 0·040 inch diameter, was found to have a resistance of 0·418 ohm. A heavy longitudinal stress causing a temporary elongation of 3 per cent., but not sufficient to produce any permanent strain, was applied, and the resistance observed was 0·422 ohm, the temperature in both cases being the same. If the resistance per meter gramme of the wire had been unaltered by the *stress*, the observed resistance of the wire under stress should have been 0·443 ohm, or some 5 per cent. more than that observed. The resistance of hardened and tempered steel wire thus appears to *decrease* 5 per cent. under stress. Experiments were next made on hard iron wire, about the same diameter as above, 1·774 metre long and 0·2274 ohm resistance. Under longitudinal stress, causing a temporary elongation of 0·33 per cent., the resistance was found to be 0·232 ohm. Now, if the wire had been unaltered in resistance by stress, the observed resistance should have been 0·229 ohm. Thus it appears that the resistance of hard or unannealed iron wire, unlike piano steel, is *increased* by stress some 1½ per cent. The figures denoting the percentage of change of resistance caused by stress are of course only approximate, but serve well to denote the direction of the change. In both sets of experiments the iron and steel wires returned to their original resistance when the stress was removed. The stress applied to the steel wire was many times that applied to the iron wire, so it is just possible that the steel wire under a small stress would have behaved like the iron wire and increased in resistance. The stress applied to both iron and steel wires was the highest they would bear without permanent change of length.

Electric Light at the Health Exhibition.—On the evening of the opening day of this exhibition a portion of the electric lighting was in service, enough to show the visitors some of the most attractive exhibits. The Hammond Company had the whole length of the western corridor lighted with bright arc lights, and also illuminated the west quadrant in like manner, causing crowds to congregate and criticise the long series of historical costumes which this indication already makes certain will be one of the most popular attractions. The entrance vestibule and the dining rooms were beautifully lighted by incandescents by the Edison-Swan United Company, and the great south gallery by Siemens with a thousand Swan incandescents as before. The former fish market, now a dining room on the Duval system, with its number of maid servants in blue serge dresses and white aprons, was lighted by many arc lights, and presented a very cool and pleasant appearance. The Central Gallery, formerly the Newfoundland Court, was again lighted by the Jablochkoff Company, the lights having a far better aspect than formerly, being now shaded by the Trotter prismatic lamp-glasses. The gardens were exceedingly beautiful with the soft light of the moon and the glitter of hundreds of Venetian lamps and Chinese lanterns, which are distributed and displayed by Mr. Pain with more even than his usual tact and talent. The windows of the corridors are arched externally with little yellow lights which form jewel-like settings to the bluish glare seen through the windows from the electric arcs within. The reflection of the various coloured tiny Vauxhall lamps in the water pools and basins, the wreaths of similar coloured lights around the pedestal of the Albert Statue, and the occasional gleams of the strong electric lights between the trees contrasting with their deep shadows combined to render the scene most charming. Two military bands added excellent music to the other outdoor attractions. This lighting and music will be continued every night. The number of visitors on the opening day exceeded 14,000.

He Forgot to Put in the Wires.—One or two good stories come from Washington anent the laying of underground cables there:—The Bankers' and Merchants' Telegraph Company in this city are putting their wires under ground. The other day they made a discovery that was amusing to others, but not to the man having in charge the underground work. He had completed the work for four squares when a thought struck him. He was very sorry that he had not been struck by it before. He had made the underground receptacle for the wires and covered it over according to the most approved methods, but he had neglected to put in the wires or anything by which they could be pulled through. He tried air pressure and everything he could devise to force a wire through the underground trough. But nothing availed. The whole thing had to be taken up and the work done over again. Mr. Morrill Marean, manager of the Washington office of the Western Union Company, told a *Critic* man about this. He continued.—"It reminds me of the time they had in London in 1857 or '58. The telegraph wires in that city have always, for the greater part, been under ground. The main wires are laid through the big tunnels, which accommodate also the gas and sewer pipes. These tunnels are big enough for a man to walk through easily. Of course there is no trouble about inspecting the wires or repairing or replacing them whenever it becomes necessary. But the pipes containing the lateral wires, running off for two or three miles from the main line, are small ones. At the time of which I speak one of these lateral wires was hauled out to be repaired. The men doing this work failed to attach to it a leading line, by which the wire could be drawn through again. The means employed to correct the error were very unique. A large rat, with a fine steel wire, was put in the pipe. Behind there was thrust a ferret. The rat ran from the ferret a short distance and stopped. It was feared that he would show fight and be killed. But he started on again. He ran through the whole length of the pipe, and brought out the wire in good style, though closely pushed by the ferret."—*The Operator*.

Professor Huxley on Science Teaching.—Professor Huxley was examined on Tuesday before the Select Committee of the House of Commons on the Education, Science, and Art Departments. He stated that in his opinion greater attention should be paid in our public schools to physical science. The Endowed Schools Commission was appointed to a great extent on account of the general state of apathy which existed in connection with the endowed schools.—Sir John Lubbock: Has it not been one of the schemes to secure that greater attention should be given to modern languages and physical science?—Yes, there is a distinct provision that a certain proportion

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of marks should be given to science and modern languages. The system, however, is not well carried out in the public schools. Not more than two hours a week are given to science. There is no doubt that the Oxford and Cambridge School Examination Board Regulations tend to handicap science extremely; but while that is the case I should be sorry to be supposed to blame the examiners, because I do not see how they can adopt a different course to that which they at present take. They found their examinations on what is taught in the schools, and the schools found their instruction on the requirements of the examiners. No doubt if the examining boards gave a greater value to science it would act as an inducement to the educational bodies to improve their system. I have not the slightest desire to interfere with the study of the classics, but I look upon the present system as wrong from top to bottom. The subjects on which most stress is laid are really luxuries, while those which are regarded as luxuries are really the most essential. For instance, it is a common thing for a young man in this country to be familiar with the classics, and to be totally unfamiliar with English literature, never having made it a study. That strikes me as a deadly harm to literature. I do not object to it as a man of science, but I object to it from my admiration for literature. In the same way as to history: it is possible for a young man to obtain the highest honours at our Universities without having any idea at all of the historical growth of his own country and the particular institutions under which he lives. In this matter science is no worse off than a great many other things. The present system of education in the country shuts out young men from many employments for which they should be eligible, and tends to the employment of foreigners.—The Chancellor of the Exchequer: You, having laid down a principle, would like to see it carried out, and would trust for its fulfilment to public opinion?—Professor Huxley: Yes; but I would give public opinion a lever through the State.—But you would really trust to immediate public opinion rather than to any active intervention on the part of a department?—No; I think an influential Minister, with a seat in the Cabinet, might do a great deal. It would be his business to judge in what direction the educational system was tending, and to enforce on the educational bodies a modification of their system in the desired direction. I would give the Minister power to insist upon more time being given to science and modern language.

Lightning and Collieries.—At the last ordinary monthly meeting of the Manchester Geological Society, Mr. John Knowles, M. Inst. C.E., read a paper describing the descent of an electric current into the New Rivin Pit, belonging to Messrs. Andrew Knowles and Sons. During a thunderstorm which took place on the 21st February a shock was felt in the workings at the New Rivin Pit, near Bolton. The colliery was about three miles from Bolton, the upcast pit being about 30 yards from the road and the downcast 50 yards. The upcast pit was 9ft. in diameter inside the brickwork, which rose as a chimney about 24ft. above the ground. In this pit there was no winding, but there was one pulley 5ft. in diameter, which stood without rope, to be used with a portable capstan engine in case of emergency. There were also two folding iron doors, which took up a space in the chimney 8ft. high by 5ft. wide. The pit was 97 yards deep. The downcast pit was also 9ft. in diameter and 97 yards deep, with a sump of 14 yards further. In the pit were four iron wire guides, 1¼in. in diameter, and two iron wire ropes between the cages; the former went into the water at the sump, and the latter terminated just below the landing plates. There were also a bell wire of galvanised iron and 3in. steam pipes mostly uncovered. The two cages were of iron, a steel rope being used for one cage and an iron rope for the other. This pit was surrounded with the ordinary cast plates and rails, but there was not any connection with the chimney of the upcast shaft. There were the usual buildings about the pits; also a chimney 6ft. square and 20 yards high, but no lightning conductor on it. At the bottom of the downcast pit there were the usual plates and rails, with the steam pipes extending to two engines on the east side and one on the west. Those going eastward were laid up a brow, with a gradient of one in three, to the Lower Three Yards mine, and then a short distance on a level to the first engine, which wound up the downbrow in this mine. At this point there was a rise tunnel to the Lower Yard mine, worked as a self-acting incline. The steam pipes were carried to the top of this tunnel, and then on a short level to the engine at the top of a downbrow in the Yard coal, where a wire rope was used to wind the coal to that point. There was also a wire rope used in that brow to work a small pump, which forced water to the top of the incline, whence it ran to the pit. On the west side the steam pipes were laid on a level in the Lower Yard mine to a small engine, which wound coal up a dip tunnel from the Lower Three Yards mine. This engine had a 6in. cylinder, with 10in. stroke, the dip tunnel being 48 yards long, with a gradient of 1 in 5. The electric current appeared to have struck the chimney at the top of the upcast pit about 2:30 p.m. on the day named. It displaced a large quantity of brickwork, and then came down outside the chimney, striking the ground close to it and making a large hole. It then went along the ground to the cast plates at the top of the downcast pit, and it was presumed went down the steam pipes and so into the workings—on the east side going through the Yard downbrow engine, and along the rope to the waggons, and on the west side passing along the pipes to the engine, where the manager was standing. The strength of the current must have been very great as experienced by a waggoner seated four or five yards from the bottom of the downcast, as he stated that he saw a brilliant flash, and heard a great noise, which sounded as if in the pit. He had the heel of his clog on one of the plates at the time, and felt a tingling sensation in his leg, which lasted a day or two, and the sole of his clog was burnt, as if hot iron had been drawn over it. Other men in the pit also experienced a sensation which they described as resembling the shock received at an electrifying machine. The manager, who was on the west side in the Lower Yard mine, at a small engine 300 yards from the pit, had his hand on the steam handle and felt a shock which numbed him for a few seconds, so that he could not see or move, and was afterwards so completely prostrated by the effects of the shock that he was confined at home to bed for six days. From the statements made by the men it would appear that there must have been a very strong current of electricity passing down the ironwork of the pit, and it was fortunate that much of it was distributed before it reached the workmen in contact with any metal. The manager being the nearest in direct contact seemed to have suffered the most, as the waggoner was only connected with the plates by a wooden clog, and others at the bottom of the Lower Yard coal incline only received a shock after it had passed many means of distribution. Two other cases of a similar kind had occurred, one at the Tanfield Moor Colliery on the 12th July, 1880, on which a paper was read before the members of the North of England Institute of Mining and Mechanical Engineers, and the other at West Thornley Colliery, on the 11th December, 1883, with regard to which a paper was also read before the same society.

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ELECTRO-CHEMISTRY.—Inorganic.

BY DR. G. GORE, F.R.S.

(CONTINUED FROM PAGE 605, VOL. XII.)

Separation of Thallium.—Tl. Electro-chemical equivalent = 204. A monad cation. Zinc coats itself with metal in solutions of salts of thallium, but tin usually does not. According to Lamy, zinc precipitates the metal from the solutions of the nitrate and sulphate in the form of brilliant crystalline laminæ. I found that crystals of silicon had no reducing effect on a solution of fluoride of thallium containing free hydrofluoric acid. According to A. Cossa, aluminium deposits by simple immersion, metallic thallium from a solution of thallium chloride at 90° C. (Watts's "Dictionary of Chemistry," Vol. VII., p. 54).

Solutions of the salts of this metal are easily decomposed by a feeble current, and the metal deposited in beautiful crystalline plates upon the cathode. I electrolysed an aqueous solution of the fluoride by a current from a single Smee's element, a thallium anode and a platinum cathode. It conducted freely, and quickly gave a metallic deposit, in long feathery crystals, like those of electro-deposited tin, but of a less white colour.

According to L. Schicht, acidulated solutions of nitrate and sulphate of thallium were not precipitated by a separate current. From ammoniacal solutions thallium was deposited upon the cathode together with much gas; whilst at the anode there appeared blackish brown thallium oxide, much resembling peroxide of lead. The current was from four Meidinger-Pincus elements, and yielded the metal in a spongy state and of a dark colour; but by using only two or three cells, fine permanently adhesive metal was obtained. From neutral solutions the metal is imperfectly precipitated on account of the acid which is liberated, but in alkaline ones the metal is bright and solid, and the deposition is complete. The deposit redissolves readily in sulphuric acid. (*Chem. News*, Vol. XLI., p. 280; also Vol. XLVII., p. 209.)

Electrolysis of Sulphate of Thallium.—TL_2SO_4. Molecular weight = 504. Aluminium immersed in a slightly acid solution of thallium sulphate, becomes coated in ten days with regular octohedra of thallium alum (Watts's "Dictionary of Chemistry," Vol. VII., p. 54). A solution of sulphate of thallium, acidulated with sulphuric acid, deposits its metal upon zinc by simple immersion (*Chem. News*, Vol. XXXVI., p. 166).

A thallium anode, in water acidulated with sulphuric acid, is converted into the black trioxide by a current from two Bunsen's cells. (Watts's "Dictionary of Chemistry," Vol. VI., p. 1,082.)

The metal is reduced from its solutions, generally from the sulphate, either by a separate current or by simple immersion of zinc. When a current from two or three Grove's cells, with platinum electrodes, is passed through an acidulated solution of thallium sulphate, dissolved in its own weight of water, the metal is deposited upon the cathode in brilliant plates, and long needle shaped crystals stretching out towards the anode. The reduction is complete when hydrogen begins to escape at the cathode. (Crookes, Watts's "Dictionary of Chemistry," Vol. V., p. 743.)

For the electrolytic analysis of compounds of thallium see L. Schicht, *Chem. News*, Vol. XLII., p. 331.

Separation of Indium.—In. Atomic weight = 113·4. A cation. This metal being very costly, but little has been done with it in electro-chemistry. It is deposited from its solutions by simple immersion of zinc in them.

According to L. Schicht, indium is completely deposited as a bluish white metal at the cathode by a separate current, both from acid and from alkaline solutions. In the latter case the metal is very bright and firm. With solutions containing organic acids, indium is also deposited in a coherent state, with abundant escape of gas. (*Chem. News*, Vol. XLI., p. 280; also Vol. XLVII., p. 209.)

For the electrolytic analysis of compounds of indium see L. Schicht, *Chem. News*, Vol. XLII., p. 331.

Separation of Tin.—Sn. Atomic weight = 118. A cation. Very few solutions of tin are available for electrolysis; the chief are stannous chloride and the aqueous solutions of stannous and stannic fluoride.

M. H. Loewel added metallic tin to a solution of green crystallised chloride of chromium free from excess of acid, in a closed glass vessel, and boiled the mixture during about 10 or 12 minutes, and then allowed it to cool. During the heating the tin combined with the chlorine of some of the chromium salt, forming stannous chloride and chromous chloride; but during the cooling the action was reversed, the chromous chloride took chlorine from the stannous chloride, and metallic tin was deposited in the form of numerous small plates (*The Chemist*, Part VIII., May, 1854, p. 476).

Electrolysis of Stannous Fluoride.—$Sn.F_2$. Molecular weight = 156. I found that zinc, immersed in a solution of stannous fluoride, produced a flocculent precipitate, and evolved gas. In the same liquid, but containing free hydro-fluoric acid, crystals of silicon did not deposit tin by simple immersion. Fremy electrolysed fused fluoride of tin in a platinum vessel; it was easily decomposed; the deposited metal alloyed with and perforated the vessel in a few minutes (*The Chemist*, New Series, Vol. II., p. 548). I electrolysed a saturated nonacid solution of stannous fluoride by means of large platinum electrodes, and a current from 10 large Smee's cells; the conduction was sparing, a little oxygen was evolved at the anode, and long feathery crystals of tin were slowly formed upon the cathode. No gas appeared at the cathode, or solid deposit at the anode. By using only one Smee's cell the deposit of tin was white, and beautiful crystals of the metal soon reached across the liquid, and completed the metallic circuit by touching the anode.

Also by passing a current from six Grove's elements by means of platinum electrodes through a strong aqueous solution of *stannic* fluoride containing little or no free hydrofluoric acid a grey deposit of tin soon appeared on the cathode. The condution was free, much gas came from the anode, and heat was evolved in the liquid. The anode was not corroded, nor did it acquire any solid deposit.

Electrolysis of Stannous Chloride.—$Sn. Cl_2$. Molecular weight = 189. Electrolytic experiments for the separation of tin are usually made with solutions containing this salt. Magnesium deposits stannic acid and spongy tin from this solution (Commaille, *Chem. News*, Vol. XIV., p. 188). A "tin tree" is produced by immersing a spiral of zinc wire in ten to twenty ounces of water in which has been dissolved three drachms of this salt and ten drops of nitric acid, and allowing the arrangement to remain undisturbed. According to Böttger, sodium amalgam in contact with a concentrated solution of stannous chloride forms a viscid amalgam. Joule obtained a beautiful crystalline amalgam by using a separate current and making mercury the cathode in this liquid. I have observed that zinc and lead become tinned by simple immersion in a solution of the salt, but antimony, bismuth, platinum, gold, silver, copper, brass, German silver, nickel, iron, and tin do not. According to Raoult, gold or copper in contact with tin in a concentrated and boiling solution of stannous chloride receive a deposit of tin; but gold in contact with antimony, silver, copper, nickel, iron, or lead receives no such coating in either the hot or cold liquid. (*Chem. News*, Vol. XXVI., p. 240; and XXVII., p. 59. Also *Jour. Chem. Soc.*, Vol. X., p. 464.)

Zinc or iron previously coated with a film of metallic copper by simple immersion process acquire a deposit of tin by simple contact with a solution composed of one part of crystals of stannous chloride, two of water, and two of hydrochloric acid (C. Paul, *Jour. Chem. Soc.*, Vol. XI., p. 955). According to Roseleur, zinc and iron become tinned by simple immersion in a boiling hot solution composed of one part of fused stannous chloride, thirty of ammonium alum, and 2,000 of water; zinc also acquires a coating of tin by simple contact with a solution of one part of fused stannous chloride and five of pyrophosphate of sodium, dissolved in 300 parts of distilled water.

Copper, brass, and bronze become coated with tin by con-

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tact during a few minutes with that metal in a boiling hot solution of peroxide of tin in caustic potash. F. Weil coats copper with tin by immersing it, in contact with zinc, in a solution formed by dissolving a salt of tin in a strong solution of caustic potash or soda, the liquid being at 50° to 100°C.; the deposit, however, contains zinc (*Chem. News*, Vol. XIII., p. 2). Dr. Hillier tins metals by immersing them in contact both with tin and zinc in a hot solution of one part of stannous chloride dissolved in 20 of water, to which has next been added one or two parts of caustic soda in 20 of water.

(TO BE CONTINUED.)

ELECTRICITY AND LIGHT.

BY JOHN T. SPRAGUE.

Electricity appears almost to realise for us one of the oldest and most striking of the representations of creative power, "Let there be light, and there was light." In most of our other sources of artificial light we appear to consume something which to the ordinary mind is converted into light. Here we have to all appearance light produced out of nothing, or as the next step from the ordinary unscientific reasoning to that of partial scientific enlightenment, *electricity converted into light*. A further advance in knowledge teaches us that—1. Electricity is not converted into light; 2, that no illuminating agent is so converted; 3, that light does not exist at all; that it is not *a thing*, but the *perception of an action*. The light is in the eye itself.

2. *Light is a Function of Energy*, and its study involves four considerations—1. The phenomena of its origin; 2, the mode of its transmission across space; 3, the nature of its perception; 4, the energy expended in these several processes. Each of these calls for and will be worth some little examination; but inasmuch as one of the great dangers of science is the acceptance of *words* (which are worthless except in so far as they convey a definite meaning) in the place of realities, it will be well to begin at an even earlier starting point. Electricity itself is a word which we all use, and which too many employ as though it were one of the old "words of power," the mere utterance of which is in itself sufficient to place the powers of nature under subjection. Yet what conflicting ideas exist as to what the word really means, and how few could give a really intelligible explanation of what they mean by it. That task we need not now attempt: but the latest of these magic names of science which we shall have much occasion to use calls for some particular consideration.

3. *What is Energy?* We have outgrown the intellectual stages at which men invented a specific fluid to answer such a question, and we recognise that we cannot say what anything *is*; we can only state the idea we form of it from its actions; we have no conception of energy except as a relation of matter and motion. It may be either expressed as the work capacity of matter in motion, or of matter under a stress capable of generating motion. But the essential feature of the modern scientific ideas as to energy is the recognition that it is uncreatable and indestructible. We can form no concrete idea of its nature; it is best conceived as *motion*, yet it is impossible even to conceive of motion apart from matter. It must therefore be recognised as an attribute of matter, yet distinct in its origin and nature, because it is transferable from one mass of matter to another, and even to that more intangible something, the *ether*. It is here, in fact, that the most usual explanations of energy fail us; we can form some sort of idea of energy in the form of work imparted to or effected by a moving mass of matter, but the imagination fails in realising the existence of vast stores of energy in mere space. It is a relief to accept the "ether," of which we know nothing, as almost representing the underlying essence of all things—the *substance* of metaphysics, endowed by the mathematician with the properties of an elastic solid, possessing none of the attributes of *matter* itself, while it is interchangeable with matter in the relations of energy.

4. *Kinetic energy* appreciable as work is the natural starting point of the endeavour to reach the unseen. A cricket ball struck by the bat gives us a perfect picture of the nature of energy, for it shows us an inert mass of matter suddenly endowed with motion, and with the capacity of doing work in consequence of that motion. We know that this capacity of doing work has been imparted to it from the muscles which moved the bat, that it is partly expended in friction of the air during its transit, and that if the motion is suddenly arrested some considerable results may be produced; in fact the ball has received, has transmitted, and has transferred that something which modern science calls "energy," and which is one of the most important elements out of which modern science is constructed.

5. *This energy can be definitely measured.* But here we should clearly recognise that, while professing to measure a thing which has after all no conceivable existence, we are merely measuring, not the thing itself, but an effect it produces. This is not an idle truism, for probably few people realise that it applies to all measurement, to all our knowledge. The most concrete idea—apparently—is that of matter, and the most apparent of our conceptions of matter is its *weight*, or in scientific terms, its mass. Yet, when we weigh a thing we are *not weighing matter itself*, we are merely measuring a *force exerted by it.* In ordinary cases we simply measure the mutual forces of attraction of the earth and the object.

6. *The most concrete measure of energy* is furnished by this very attraction, viz., the unit of mechanical work, the foot-pound, the energy imparted to a pound weight while moving through one foot of space under the force of the earth's attraction, or which must be expended in lifting that pound weight against the earth's attraction.

7. *Heat gives us another concrete unit* in the quantity of heat, which is now known to be an action of energy, necessary to raise one pound of water one degree of temperature. Here again, however, we have to recognise that we cannot measure a thing itself, but only its effects. We speak of a *quantity of heat*, but we never measure *heat itself;* we measure either a temperature effect, variable in every separate substance, and necessary to be ascertained by experiment, or we measure an expansion effect variable also in every substance except in pure gases.

8. *The correlation of the forces*, the knowledge of which is the greatest achievement of this age, as far as pure science is concerned, because it is the starting point of progress of discovery in all directions, means that many actions which used to be attributed to special fluids or *forces* are merely different manifestations of *energy*. It follows, therefore, that one unit of energy can represent all these actions; that is to say, that just as a quantity of heat contained in a mass of red hot iron can be expressed in terms of the number of pounds of water it will raise 1° F. in temperature when the relations are ascertained, so can it equally be expressed in foot-pounds of mechanical work once the inter-relation of these actions of energy is ascertained.

9. *The action of heat on a pure gas* is the most apparent evidence of this relation, although not the one by which it is usually illustrated. We can impart heat to a gas in two ways. 1. The gas being enclosed in a rigid vessel and heated, a certain number of degrees exhibits that heat in the form of temperature, just as water or iron does; this is the *heat of constant volume.* Under these circumstances a force is also developed—a pressure or tendency to expand. 2. The gas may be allowed to expand freely while heating, and will now absorb what is called the *heat of constant pressure.* Now if we pass the gas into a calorimeter we shall find that the heat of this second case is the greater by a measureable quantity. But as the same quantity of gas is at the same temperature in each case, how has this excess of heat been disposed of so as not to be apparent, and yet capable of being recovered? Something else has been done besides heating the gas; the art of expansion involved the lifting a column of the atmosphere, and this work can be measured in foot-pounds. This work therefore represents the energy corresponding to the difference of the two heats. Various experimental conversions have been made resulting in the two figures of 772 foot-pounds and

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1lb. 1° F. of water, which are received as the "mechanical equivalent of heat;" that is to say, the same quantity of energy will appear as either of the two forms, and 1lb. of water falling 772 feet would be heated 1° if it could be stopped so as to retain in itself the whole energy of the earth's attraction.

10. *Potential energy* is more difficult to conceive than kinetic, but our cricket ball may furnish some ideas. When it is flying through space it is not doing work, except as friction in the air; but it has the capacity to do work, and this friction work is a gradual exertion of that capacity. Its motion at each instant is therefore the measure of its remaining capacity, and is in fact the consequence of and the evidence of the energy *potential* or latent in the ball. Now the unscientific mind would imagine that this energy was created by the striker, the production of his will; but science knows that the player no more created the energy than the bat did. The player in exerting his muscles burnt away a portion of their material or consumed some of the substance stored in his blood and derived from his food; in fact, he corresponds in function to a steam engine and boiler fed with coal. We come then to the result that he simply transferred *potential* energy to the ball, converting it first into *kinetic* energy or mechanical work in his muscles. The food itself simply stored up energy derived from the sun's beams, because the process of vegetable life is a continual *unburning* of hydrogen in water and carbon in carbonic acid, and the setting free of oxygen in the air, a process which requires an equivalent of energy to be imparted to the atoms, which energy they give up on their re-union, whether in the lungs and muscles of the cricket player or the boiler of the steam-engine.

ON MECHANICAL DYNAMOMETERS.

BY GISBERT KAPP.

(CONTINUED FROM PAGE 539, VOL. XII.)

Another very ingenious contrivance depending upon gravity is H. Darwin's dead-weight rotary dynamometer,* which is

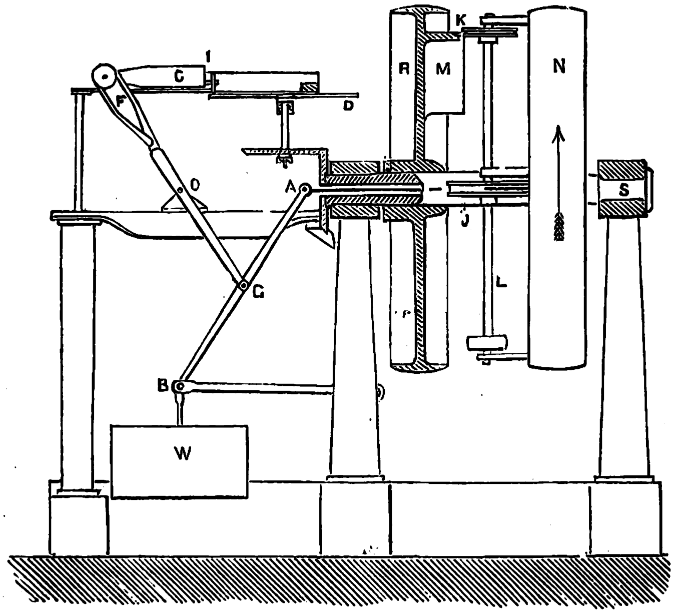

FIG. 27.—Darwin's Dead-Weight Rotary Dynamometer.

shown in elevation in Fig. 27. The power is received on pulley N (which is keyed fast on the shaft S), and is transmitted to the machine under test by a belt from pulley R. The latter is loose on the shaft, but is carried round by a chain, one end of which is attached to the sector M, whilst the other end is wound on to the small wheel K. This wheel is keyed to a spindle L L, supported in bearings which are fastened to pulley N, and is thus forced to revolve with that pulley. Another wheel, J, is keyed to about the middle of shaft L, and enters partly into a slot cut out in shaft S. The object of this is to bring a chain, which is wound on wheel J, exactly into the centre of the shaft, where it is fastened to a flat bar, passing through a central hole, and ending with a swivel joint at A. A G B is a lever pivoted at G, and carrying at B a weight, W, which tends to pull the bar out from the shaft, thus uncoiling the chain wound on T, and coiling more chain on to wheel K, the two chains being wound in opposite directions. Conversely, a twisting strain or torque between the pulleys N and R will result in partly uncoiling the chain wound on K, and coiling more on to J, whereby the bar is drawn further into the shaft, and the weight is raised. The fulcrum G of the lever A B is not fixed, but is formed by the lower end of another lever G O F, which is pivoted in a fixed point, O, and the upper end of which is provided with a fork, F, by which the position of the integrating wheel T is controlled. D D is the disc driven by bevel gear at a speed proportional to that of the pulleys, and C is a counter by which the mechanical energy transmitted during any given time is recorded. One important feature of this dynamometer is that the horizontal displacement of the integrating wheel is exactly proportional to the torque between the two pulleys, and that therefore the integration performed by the recording apparatus is mathematically correct. To prove this let, in Fig. 28, A P represent the pull on the bar, that is, a force proportional to the torque transmitted; let B W represent the weight which is attached to the lower end

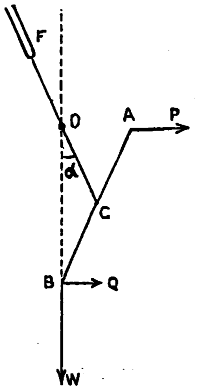

FIG. 28.

of the lever A G B, and O G the lower arm of the lever, which by a fork, F, controls the position of the integrating wheel. The displacement of this wheel is of course proportional to tang α, α being the angle to which the lever O G is pulled away from the vertical by the force A P. If O G = A G = B G, the three points A, O and B must be on a circle described from G as a centre, and if A be guided horizontally and B vertically the direction of both forces P and W must be through the fixed fulcrum O, and their magnitude must be as the corresponding sides of the rectangular triangle A O B inscribed into the semi-circle. We would thus have the equation

$$P = W \text{ tang } \alpha.$$

There is, however, one objection which might be raised against this reasoning, viz., that the guiding of the points A and B in a horizontal and vertical line respectively might introduce certain reacting forces (in a vertical direction on A and in a horizontal direction on B) which would invalidate the above equation. It is easy to show that these points would move in straight lines, even if not forced to do so by guides, or, in other words, that the guides do not react on these points. To prove this, assume that on the long radius rod guiding B (Fig. 27) in an arc, which for a small vertical displacement can without error be substituted for its tangent, there were a reaction Q in a horizontal direction. Replacing the forces P, W and Q by their components taken parallel and vertical to A B, we find one condition of equilibrium for this lever to be

$$P \cos \alpha = W \sin \alpha + Q \cos \alpha \quad . \quad . \quad . \quad . \quad (1)$$

Let T represent the total pull on the second lever in the direction O G, and substitute for it also its components, we

* *Proceedings* Institution of Mechanical Engineers, July, 1876.

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find that the vertical component is

$$T \sin 2\alpha,$$

and the parallel

$$T \cos 2\alpha.$$

Since both arms of the lever A B are equal, the reaction in its fulcrum must be twice as great as the force applied on either end, that is

$$2 P \cos \alpha = T \sin 2\alpha \quad . \quad . \quad . \quad . \quad (2)$$

The components taken parallel to A B of the various forces acting in A, G and B must be in equilibrium amongst themselves, which gives the equation

$$P \sin \alpha + T \cos 2\alpha + Q \sin \alpha = W \cos \alpha,$$

which, combined with (2), gives

$$P + Q\, tg^2 \alpha = W\, tg\, \alpha.$$

But from equation (1) it follows that

$$P - Q = W\, tg\, \alpha,$$

and it is evident that these equations can only coexist if $Q = 0$.

In the same way it can be proved that a guide in A cannot produce any vertical pressure on that point; in fact, if the lower end of the lever is guided in a vertical line the upper end will of itself move along a horizontal, and thus make a second guide unnecessary. Having now proved that the equation

$$P = W\, tg\, \alpha$$

is rigorously correct, and remembering that the displacement of the integrating wheel from the centre of the disc is by reason of the sliding fork-attachment also proportional to $tg\, \alpha$, we find that

$$P = cr$$

where P can now be taken to represent the torque or power transmitted to the machine under test, c is a constant, and r is the radial displacement of the integrating wheel on the face of the disc D D.

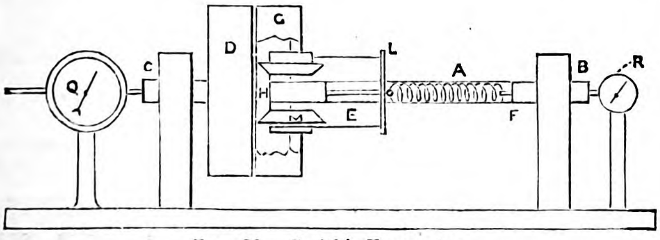

FIG. 29.—Smith's Ergometer.

Although this instrument does not seem to have met with much practical success, it forms one of the most interesting and ingenious contrivances for integrating energy transmitted, and the peculiar arrangement of levers just described deserves to be more widely known, as it may prove useful for some other application.

A somewhat similar instrument, but without integrating apparatus, is Emmerson's transmission dynamometer, intended for use in factories for measuring, or rather indicating, at any moment the amount of power flowing from the main shaft into that particular tool to which it is fitted. In this case the instrument takes the place of the usual overhead motion, and consists of a short countershaft provided with two pulleys, of which one is fast and drives on to the tool, the other is loose and connected by a belt with the main shaft. A system of bell-crank levers and sliding pieces (corresponding in Darwin's dynamometer to the chains, wheels and sliding bar) connect the loose pulley to a hub sliding on a fast feather on the shaft and transmitting to it the rotation of that pulley, whilst displacing at the same time the hub longitudinally on the shaft to a greater or lesser amount, according to the power transmitted. This displacement is partly resisted by a collar, bell-cranks, tension-rod and weight swinging on a radial arm and in front of a quadrant, on which, by means of a suitable scale, the power transmitted can at any moment be read off. The scale can of course be only correct for one definite speed of the main shaft, but since that is very nearly a constant speed in most factories the dynamometer overhead motion fitted to each tool can be calibrated for that constant speed and would thus show at a glance the power absorbed by each tool.

Fig. 29 shows F. T. Smith's transmission ergometer. This dynamometer has as usual two pulleys, D fast and G loose. To the former is fixed a bevel wheel, H, and to the latter are attached bearings for two other bevel wheels, K and M, both in gear with H, and each provided with a drum upon which a steel cord is coiled, the direction being opposite on the two drums. The cords are attached to a cross-bar, L, passing through the shaft C B, which is tubular at each end, and link-shaped between E F, and the centre of this cross-bar is fastened to a spiral spring A, which is elongated in proportion to the twisting couple which is being transmitted from D to G by means of the bevel gear. The speed is taken from a speed indicator, R, and the tension of the spring—that is the torque transmitted—is made known by the pointer of the dial Q, which is worked by a rod passing through the hollow shaft. Since the spring is placed into the centre of the shaft it is unaffected by centrifugal force. Fig. 30 is a full view of the apparatus as applied to a magneto machine, and the author is indebted to the inventor for the loan of this drawing. Mr. Smith has greatly improved existing and also invented new appliances for use in dynamometric tests. As a detailed account of these will be found in a little pamphlet* only recently published, it will not be necessary to describe these appliances here at length, and we must be content to merely mention a few. One of these is the testing of a small electromotor by suspending its field-magnets on centres, and measuring by a lever and weight or spring the power required to keep the field-magnets from revolving. This plan was first used in 1881 on some Trouvé motors. Another is an improvement in White's dynamometer, whereby a continuous diagram and record of the power transmitted is obtained, and also deserves mention. Mr. Smith has devised several integrating instruments. In one of these the volume of water delivered by a little pump is made to be in direct proportion with the work passing through the dynamometer. The pump is driven at the same or a proportional speed to the dynamometer, but its stroke is variable by means of a link and sliding block. The position of the block being controlled in accordance with the torque transmitted, the volume of water delivered by the pump is an exact measure of the energy. Another instrument is the ratchet and sink integrator, organically the same as the hydraulic integrator, but instead of a double acting pump two ratchet wheels are employed. The usual integrating wheel already often mentioned in these articles has been improved by Mr. Smith so as to move over the face of the disc with practically no friction. This is attained by providing the rim of the integrating wheel with a number of small rollers, and thus changing what formerly was a scraping movement into smooth rolling. To indicate the speed Mr. Smith employs a modification of Ramsbottom's well-known velocimeter, substituting mercury and tinted water for oil, or a telephonic arrangement depending upon the isochronic movement of two wheels, one driven by the machine, the other by hand. This method is especially recommended for testing small motors. The power necessary to drive an ordinary speed counter or speed indicator, although small enough in itself, is yet sufficiently large to be felt by a small motor. In these cases the speed can be found either by employing Mr. Smith's telephonic arrangement or by a phonetic wheel, or by a very light train of clockwork driven by an endless fine cotton thread from a small grooved wheel on the spindle of the motor to a large wheel on the quickest shaft of the clockwork, a plan which the author has found to answer very well. If the frame of the clockwork be pivoted on centres with a light spring to pull it against the driving thread there will be no loss of speed from slipping, and yet the power to drive the clockwork is so small that it can be neglected even if testing very small motors.

(TO BE CONTINUED.)

* "Work Measuring Machines." By F. Y. Smith. E. and F. N. Spon, London.

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THE PROTECTION OF SUBMARINE TELEGRAPH CABLES.

The following is the English translation of a despatch, signed at Paris on March 14 last, from Lord Lyons to the Secretary of State for Foreign Affairs, on the subject of the Protection of Submarine Telegraph Cables :—

Viscount Lyons to Earl Granville.—(Received March 22.)

(Extract.) Paris, March 21, 1884.

I have the honour to transmit herewith to your lordship, in original, the Convention for the protection of submarine cables, signed on the 14th instant by myself, on the part of Great Britain, and by the Plenipotentiaries of the twenty-five other States parties to it, on behalf of their respective Governments.

I transmit also the *procès-verbal* of signature, which was signed by the other Plenipotentiaries and myself on the 14th March.

Your lordship will observe that the *procès-verbal* contains a provision that the exchange of the ratifications of the Convention shall be made through the French Government.

(Enclosure I.)

Her Majesty the Queen of the United Kingdom of Great Britain and Ireland, Empress of India, His Majesty the German Emperor, King of Prussia, His Excellency the President of the Argentine Confederation, His Majesty the Emperor of Austria, King of Bohemia, &c., and Apostolic King of Hungary, His Majesty the King of the Belgians, His Majesty the Emperor of Brazil, His Excellency the President of the Republic of Costa Rica, His Majesty the King of Denmark, His Excellency the President of the Dominician Republic, His Majesty the King of Spain, His Excellency the President of the United States of America, His Excellency the President of the United States of Colombia, His Excellency the President of the French Republic, His Excellency the President of the Republic of Guatemala, His Majesty the King of the Hellenes, His Majesty the King of Italy, His Majesty the Emperor of the Ottomans, His Majesty the King of the Netherlands, Grand Duke of Luxemburg, His Majesty the Shah of Persia, His Majesty the King of Portugal and the Algarves, His Majesty the King of Roumania, His Majesty the Emperor of all the Russias, His Excellency the President of the Republic of Salvador, His Majesty the King of Servia, His Majesty the King of Sweden and of Norway, and His Excellency the President of the Oriental Republic of the Uruguay, being desirous to secure the preservation of telegraphic communications made by means of submarine cables, have resolved to conclude a Convention for this purpose, and have named for their Plenipotentiaries, that is to say :

Her Majesty the Queen of the United Kingdom of Great Britain and Ireland, Empress of India : his Excellency the Right Honourable Richard Bickerton Pemell, Viscount Lyons, a Peer of the United Kingdom of Great Britain and Ireland, Member of Her Britannic Majesty's Privy Council, Her Ambassador Extraordinary and Plenipotentiary to the Government of the French Republic, &c., &c. ;

His Majesty the Emperor of Germany, King of Prussia : his Highness Prince Chlodwig Charles Victor de Hohenlohe-Schillingfürst, Prince de Ratibor and Corvey, Grand Chamberlain of the Crown of Bavaria, his Ambassador Extraordinary and Plenipotentiary to the Government of the French Republic, &c., &c.;

His Excellency the President of the Argentine Confederation : M. Balcarce, Envoy Extraordinary and Minister Plenipotentiary of the Confederation at Paris, &c., &c.;

His Majesty the Emperor of Austria, King of Bohemia, &c., and Apostolic King of Hungary : his Excellency Count Ladislas Hoyos, Actual Privy Councillor, his Ambassador Extraordinary and Plenipotentiary to the Government of the French Republic, &c., &c.;

His Majesty the King of the Belgians : Baron Beyens, his Envy Extraordinary and Minister Plenipotentiary at Paris, &c., &c. ; and M. Léopold Orban, Envoy Extraordinary and Minister Plenipotentiary, Political Director-General in the Department for Foreign Affairs of Belgium, &c., &c. ;

His Majesty the Emperor of Brazil : M. d'Araujo, Baron d'Itajuba, Brazilian Chargé d'Affaires at Paris, &c., &c. ;

His Excellency the President of the Republic of Costa Rica : M. Léon Somzée, Secretary of the Costa Rican Legation at Paris, &c., &c. ;

His Majesty the King of Denmark : Count Moltke-Hvitfeldt, his Envoy Extraordinary and Minister Plenipotentiary at Paris, &c., &c. ;

His Excellency the President of the Dominican Republic : Baron de Almeda, Minister Plenipotentiary of the Dominican Republic at Paris, &c., &c. ;

His Majesty the King of Spain : His Excellency M. Manuel Silvela de le Vielleuse, Permanent Senator, Member of the Spanish Academy, his Ambassador Extraordinary and Plenipotentiary to the Government of the French Republic, &c., &c. ;

His Excellency the President of the United States of America : Mr. L. P. Morton, Envoy Extraordinary and Minister Plenipotentiary of the United States of America at Paris, &c., &c., and Mr. Vignaud, Secretary of the Legation of the United States of America at Paris, &c., &c. ;

His Excellency the President of the United States of Colombia : Dr. José G. Triana, Consul-General of the United States of Colombia at Paris, &c., &c. ;

His Excellency the President of the French Republic : M. Jules Ferry, Deputy, President of the Council, Minister for Foreign Affairs, &c., &c., and M. Adolphe Cochery, Deputy, Minister of Posts and Telegraphs, &c., &c. ;

His Excellency the President of the Republic of Guatemala : M. Crisanto Medina, Envoy Extraordinary and Minister Plenipotentiary of the Republic of Guatemala at Paris, &c., &c. ;

His Majesty the King of the Hellenes : Prince Maurocordato, his Envoy Extraordinary and Minister Plenipotentiary at Paris, &c., &c. ;

His Majesty the King of Italy : his Excellency General Count Menabrea, Marquis de Valdora, his Ambassador Extraordinary and Plenipotentiary to the Covernment of the French Republic, &c., &c. ;

His Majesty the Emperor of the Ottomans : his Excellency Essad Pasha, his Ambassador Extraordinary and Plenipotentiary to the Government of the French Republic, &c., &c. ;

His Majesty the King of the Netherlands : Grand Duke of Luxemburg, Baron de Zuylen de Nyevelt, his Envoy Extraordinary and Minister Plenipotentiary at Paris, &c., &c. ;

His Majesty the Shah of Persia : General Nazare Aga, his Envoy Extraordinary and Minister Plenipotentiary at Paris, &c., &c. ;

His Majesty the King of Portugal and the Algarves : M. d'Azevedo, Portuguese Chargé d'Affaires at Paris, &c., &c. ;

His Majesty the King of Roumania : M. Odobesco, Roumanian Chargé d'Affaires *ad interim* at Paris, &c., &c. ;

His Majesty the Emperor of all the Russias : his Excellency Aide-de-camp General Prince Nicolas Orloff, his Ambassador Extraordinary and Plenipotentiary to the Government of the French Republic, &c., &c. ;

His Excellency the President of the Republic of Salvador : M. Torrès-Caïcedo, Envoy Extraordinary and Minister Plenipotentiary of the Republic of Salvador at Paris, &c., &c. ;

His Majesty the King of Servia : M. Marinovitch, his Envoy Extraordinary and Minister Plenipotentiary at Paris, &c., &c. ;

His Majesty the King of Sweden and of Norway : M. Sibbern, his Envoy Extraordinary and Minister Plenipotentiary at Paris, &c., &c. ;

His Excellency the President of the Oriental Republic of the Uruguay : Colonel Diaz, Envoy Extraordinary and Minister Plenipotentiary of the Oriental Republic of the Uruguay at Paris, &c., &c. ;

Who, after having exchanged their full powers, found in good and due form, have agreed upon the following Articles :—

ARTICLE I.—The present Convention applies outside territorial waters to all legally established cables landed on the territories, colonies, or possessions of one or more of the high contracting parties.

ARTICLE II.—It is a punishable offence to break or injure a submarine cable, wilfully or by culpable negligence, so as to interrupt or obstruct telegraphic communication, either wholly or partially, such punishment being without prejudice to any civil action for damages.

This provision does not apply to cases where those who break or injure a cable do so with the lawful object of saving their lives or their ship, after they have taken every necessary precaution to avoid so breaking or injuring the cable.

ARTICLE III.—The high contracting parties undertake that, on granting a concession for landing a submarine cable, they will insist upon proper measures of safety being taken, both as regards the track of the cable and its dimensions.

ARTICLE IV.—The owner of a cable who, on laying or repairing his own cable, breaks or injures another cable, must bear the cost of repairing the breakage or injury, without prejudice to the application, if need be, of Article II. of the present Convention.

ARTICLE V.—Vessels engaged in laying or repairing submarine cables shall conform to the regulations as to signals which have been, or may be, adopted by mutual agreement among the high contracting parties, with the view of preventing collisions at sea.

When a ship engaged in repairing a cable exhibits the said signals, other vessels which see them, or are able to see them, shall withdraw to or keep beyond a distance of 1 nautical mile at least from the ship in question, so as not to interfere with her operations.

Fishing gear and nets shall be kept at the same distance.

Nevertheless, fishing-vessels which see or are able to see a telegraph ship exhibiting the said signals, shall be allowed a period of twenty-four hours at most within which to obey the notice so given, during which time she shall not be interfered with in any way.

The operations of the telegraph ships shall be completed as quickly as possible.

ARTICLE VI.—Vessels which see, or are able to see, the buoys showing the position of a cable when the latter is being laid, is out of order, or is broken, shall keep beyond a distance of one-quarter of a nautical mile at least from the said buoys.

Fishing nets and gear shall be kept at the same distance.

ARTICLE VII.—Owners of ships or vessels who can prove that they have sacrificed an anchor, a net, or other fishing gear in order to avoid injuring a submarine cable shall receive compensation from the owner of the cable.

To be entitled to such compensation, a statement, supported by the evidence of the crew, must, whenever possible, be drawn up immediately after the occurrence ; and the master must, within twenty-four hours after arriving at his destination, or on next putting into a port, make a declaration to the proper authorities.

The latter shall communicate the information to the consular authorities of the country to which the owner of the cable belongs.

ARTICLE VIII.—The tribunals competent to take cognisance of infractions of the present Convention are those of the country to which the vessel on board of which the offence was committed belongs.

It is, moreover, understood that, in cases where the provisions in the previous paragraph cannot apply, offences against the present Convention

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will be dealt with in each of the contracting States in accordance, so far as the subjects and citizens of those States respectively are concerned, with the general rules of competence prescribed by the municipal laws of that State, or by international treaties.

ARTICLE IX.—Prosecutions for infractions provided against by Articles II., V., and VI. of the present Convention shall be instituted by the State, or in its name.

ARTICLE X.—Offences against the present Convention may be verified by all means of proof allowed by the legislation of the country of the Court. When the officers commanding the ships of war, or ships specially commissioned for the purpose by one of the high contracting parties, have reason to believe that an infraction of the measures provided for in the present Convention has been committed by a vessel other than a vessel of war, they may demand from the captain or master the production of the official documents proving the nationality of the said vessel. The fact of such document having been exhibited shall then be endorsed upon it immediately. Further, formal statements of the facts of any offence may be prepared by the said officers, whatever may be the nationality of the vessel on board of which the offence has been committed. These formal statements shall be drawn up in the form and in the language used in the country to which the officer making them belongs; they may be considered, in the country where they are adduced, as evidence in accordance with the laws of that country. The accused and the witnesses shall have the right to add, or to have added, thereto, in their own language, any explanations they may consider useful. These declarations shall be duly signed.

ARTICLE XI.—The proceedings and trial in cases of infraction of the provisions of the present Convention shall take place as summarily as the laws and regulations in force will permit.

ARTICLE XII.—The high contracting parties engage to take or to propose to their respective Legislatures the necessary measures for insuring the execution of the present Convention, and especially for punishing, by either fine or imprisonment, or both, those who contravene the provisions of Articles II., V., and VI.

ARTICLE XIII.—The high contracting parties will communicate to each other laws already made, or which may hereafter be made, in their respective countries, relating to the object of the present Convention.

ARTICLE XIV.—States which have not signed the present Convention may adhere to it on making a request to that effect. This adhesion shall be notified diplomatically to the Government of the French Republic, and by the latter to the other Signatory Powers.

ARTICLE XV.—It is understood that the stipulations of the present Convention do not in any way restrict the freedom of action of belligerents.

ARTICLE XVI.—The present Convention shall be brought into force on a day to be agreed upon by the high contracting Powers.

It shall remain in force for five years from that day, and unless any of the high contracting parties have announced, twelve months before the expiration of the said period of five years, its intention to terminate its operation, it shall continue in force for a period of one year, and so on from year to year.

If one of the Signatory Powers denounce the Convention, such denunciation shall have effect only as regards that Power.

ARTICLE XVII.—The present Convention shall be ratified, and the ratifications exchanged at Paris with as little delay as possible, and, at the latest, at the expiration of a year.

In witness whereof the respective Plenipotentiaries have signed the same, and have affixed thereto their seals.

Done in twenty-six copies, at Paris, the 14th day of March, 1884.

(Signed)
(L.S.) LYONS.
(L.S.) HOHENLOHE.
(L.S.) M. BALCARCE.
(L.S.) LADISLAS, Comte HOYOS. (Signed)
(L.S.) BEYENS. (L.S.) LÉOPOLD ORBAN.
(L.S.) Baron D'ITAJUBA.
(L.S.) LÉON SOMZÉE.
(L.S.) EMANUEL DE ALMEDA.
(L.S.) MOLTKE-HVITFELDT.
(L.S.) MANUEL SILVELA.
(L.S.) L. P. MORTON. (L.S.) HENRY VIGNAUD.
(L.S.) JOSÉ G. TRIANA.
(L.S.) JULES FERRY. (L.S.) A. COCHERY.
(L.S.) CRISANTO MEDINA.
(L.S.) MAUROCORDATO.
(L.S.) L. L. MENABREA.
(L.S.) ESSAD.
(L.S.) Baron de ZUYLEN DE NYEVELT.
(L.S.) NAZARE AGA.
(L.S.) F. D'AZEVEDO.
(L.S.) ODOBESCO.
(L.S.) Prince ORLOFF.
(L.S.) J. M. TORRÈS-CAÏCEDO.
(L.S.) J. MARINOVITCH.
(L.S.) G. SIBBERN.
(L.S.) JUAN J. DIAZ.

ADDITIONAL ARTICLE.—The stipulations of the Convention concluded under to-day's date for the protection of submarine cables shall be applicable, in conformity with Article I., to the Colonies and possessions of Her Britannic Majesty, with the exception of those hereinafter mentioned, namely:—Canada, Newfoundland, the Cape, Natal, New South Wales, Victoria Queensland, Tasmania, South Australia, Western Australia, New Zealand. Provided always that the stipulations of the said Convention shall be applicable to any of the above-named Colonies or possessions on whose behalf notice to that effect shall have been given by Her Britannic Majesty's representative at Paris to the French Minister for Foreign Affairs.

Each of the above-named Colonies or possessions which may have acceded to the said Convention shall be at liberty to withdraw from it in the same manner as the Powers parties to it. In the event of any of the said Colonies or possessions desiring to withdraw from the Convention, a notification to that effect shall be made by Her Britannic Majesty's Representative at Paris to the French Minister for Foreign Affairs.

(Signed)
(L.S.) LYONS.
(L.S.) HOHENLOHE.
(L.S.) M. BALCARCE.
(L.S.) LADISLAS, Comte HOYOS. (Signed)
(L.S.) BEYENS. (L.S.) LÉOPOLD ORBAN.
(L.S.) Baron D'ITAJUBA.
(L.S.) LÉON SOMZÉE.
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(L.S.) J. MARINOVITCH
(L.S.) G. SIBBERN.
(L.S.) JUAN J. DIAZ.

(Enclosure II.)

After having communicated their full powers, the Plenipotentiaries collated the texts of the Convention which had been prepared in a number equal to that of the contracting States, and all these documents having been found in good and proper form, the Plenipotentiaries affixed thereto their signatures and the seal of their arms.

On signing the Convention, his Excellency Lord LYONS made the following declaration in the name of his Government:—

"Her Majesty's Government takes Article XV. to mean that in time of war, a belligerent, who is Signatory to the Convention, will be free to act, with respect to submarine cables, as if the Convention did not exist."

Formal note was taken of this declaration on the part of his Excellency the Ambassador of Great Britain.

M. LÉOPOLD ORBAN read the following declaration in the name of the Belgian Government:—

"The Belgian Government, through its delegate at the Conference, has maintained that the Convention has no effect on the rights of belligerent Powers; these rights would be, after signing, neither more nor less extended than they are at present. The reference inserted in Article XV., though absolutely useless in the view of the Belgian Government, would not justify it in refusing to join in an object the importance of which was beyond dispute."

Formal note was taken of this declaration of M. Léopold Orban.

Baron de ZUYLEN DE NYEVELT stated that the Netherlands Government, in signing the Convention, could undertake to accede at present only as regards the mother country. It reserved to itself the power to accede later to this Convention for the whole or for part of its colonies or possessions.

Formal note was taken of this declaration of the Minister of the Netherlands.

The Minister of SWEDEN and NORWAY stated that his instructions require him to reserve, in signing the Convention, the subsequent approval of the legislatures of the United Kingdoms.

The PRESIDENT took formal note of this declaration of the Minister of Sweden and Norway, while observing further that the reservation for the fulfilment of the formalities required by the different constitutions, before exchanging the ratifications of the Convention, was the right of all the contracting States.

Taking into consideration the large number of the contracting parties, and following the method of proceeding already adopted at the time of the ratification of the treaties relative to the redemption of the Sound dues and Scheldt tolls, of the Telegraph Convention at Paris, and of the Metre Convention, it was agreed, on the motion of the President, that the exchange of ratifications for the protection of submarine cables should be effected through the Government of the French Republic.

The Plenipotentiaries decided further that the document which had just been signed should be brought to the cognisance of all the non-Signatory States, which should be invited to take advantage of the power of accession which is reserved to them by Article XIV. of the Convention.

It was agreed that this communication should be left to the care of the French Minister for Foreign Affairs. The Government of the French Republic would likewise receive notifications of accession which might come in before the date fixed for the Convention to come into force.

The present minutes, drawn up during the sitting, having been read and approved, the Conference separated at three o'clock.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

We cannot undertake to return drawings or manuscripts, and must therefore request Correspondents to keep copies.

All letters intended for insertion in The Electrician, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

SUBSCRIPTIONS.

The Electrician *can be had, by order, from any newsagent in town or country, at the various railway stations; or it can, if preferred, be supplied direct from the office, on the following terms (paid in advance):—*

	3 months. s. d.	6 months. s. d.	12 months. s. d.
For United Kingdom	4 11	9 9	19 6
,, Foreign Parts and Colonies:— Within Postal Union	5 6	11 0	22 0
,, Labuan, Persia, Aden, Mozambique, Zanzibar, India, China, Japan, Borneo, Java, Philippine Islands, & New Caledonia	6 1	12 1	24 2

Cheques and P.O. Orders to be made payable to C. H. W. Biggs.

Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes ... 1
Electro-Chemistry. By Dr. G. Gore, F.R.S. (Continued.) ... 6
Electricity and Light. By John T. Sprague ... 7
On Mechanical Dynamometers. By Gisbert Kapp. Illustrated. (Continued.) ... 8
The Protection of Submarine Telegraph Cables ... 10
Telegraphs and News Agencies ... 12
Correspondence ... 13 to 15
The Diameter of Conductors to Prevent Overheating in Electric Currents. By G. Forbes ... 16
Literature ... 18
Magnetism and Electricity. By C. F. Chandler ... 18
Society of Telegraph Engineers and of Electricians ... 21
Legal ... 22 to 24
Submarine Cables Trust ... 24
Companies' Share List ... 24
Traffic Receipts ... 24

IMPORTANT NOTICE.

*** All communications should be sent to our new offices, 1, Salisbury-court, Fleet-street, E.C., where *The Electrician* is now printed and published.

THE INDEX TO VOL. XII.

With our present issue is published the Index to Vol. XII., which every Subscriber should receive Gratis.

TELEGRAPHS AND NEWS AGENCIES.

It is not surprising that the result of the action brought against the Eastern Telegraph Company by the Central News has given little satisfaction to the newspapers. To begin with, they had expected a great scandal; secondly, they had hoped that an injustice alleged to have been done to one of their emissaries would be severely punished; and lastly, they had persuaded themselves that telegrams sent by their accredited correspondents would be declared inviolable. On all these points the newspapers have been rudely undeceived, and, we venture to add, disappointed. The scandal, what there was of it, got fixed on the other shoulders; the wrong, if there was any, was not committed by the defendants; and as to the inviolability of telegrams, their violation has been strongly upheld on grounds of public policy. The lesson taught by this trial will be valuable to newspaper correspondents and to news agencies for all future time; but they have not taken it very kindly, and it is evident that a quite different lesson was expected—one which the telegraph companies would have to take to heart, not their customers.

But when all due allowance has been made for these natural disappointments there still remains a good deal that is altogether unreasonable, and even absurd, in the comments which newspapers have indulged in on this case. Nothwithstanding the proved innocence of the defendants on the one hand, and the proved indiscretion—to use no stronger phrase—of the plaintiffs, the Press have almost uniformly treated the verdict as if it had been given on a technical issue, instead of being, as it actually was, decided upon the undisputed facts revealed in the course of the trial. We are unable to admit even, that had the defendants' case been known beforehand the plaintiffs would not have proceeded with theirs; for when it did become known the trial was pushed on all the same, a circumstance which lent some colour to the plea of the defendants that the action was a spiteful one, and deserved the defeat it sustained in open court. It is impossible to acquit the newspapers of partiality in this respect; if anybody but a news agent had been guilty of obtaining evidence in the manner confessed to by the plaintiffs, and of employing testimony which a little careful inquiry would have shown to be false, the newspapers would have reserved their virtuous indignation for him, and not be now wasting it on people who were proved to have committed no wrong whatever, either moral or legal.

Now we make bold to demur to the proposition that any wrong was done the Central News Company, and we take our stand on public grounds. One of the newspapers above referred to puts it that Mr. Burleigh's telegram having being forwarded in the interests of the public, the public suffered through its being forestalled. This is mere cant; we have too high an opinion of the business capacity of news agencies to suppose that they labour for the public, and if we had any doubt on this point it would be removed by the contention put forward at the trial. For what does it really amount to? Why, that a newspaper correspondent may block the wires as long as he pleases, and thus *prevent* the public receiving any news until he chooses to leave off writing. There is another contention equally extravagant, and more openly avowed than the one just mentioned, namely, that although the news which is being transmitted is public property all along the route it must not be made use of until the newspaper agent's telegram has dragged its weary length to its destination. This disposes of the affectation of acting for the public good. The public wants early information, and it is a matter of indifference to them who sends or who brings the information.

But, say the friends of the plaintiffs, the indiscretion of the agent in sending a telegram of such inordinate length does not justify its being "milked" on the way. To this we reply, again on public grounds, that milking was perfectly justified in the circumstances. It is by no means certain that it occurred; to assume that it did occur would be to assert that the news of a great victory well known at Kassassin would not travel over the military wire between that place and Ismailia independently of Mr. Burleigh, an assertion which can only provoke a smile among people who know anything of telegraphy during exciting times, especially where military wires are concerned. But even admitting that the only information available was that obtained from the heroic, but effusive, newspaper correspondent, can it be contended that the military authorities—that is to say, the real servants of the public, whose business it was to obtain information—would wilfully shut their eyes to the Burleigh telegram because it happened to be addressed to a news agency in London? If the sender imagined that his

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telegram would be treated as an inviolable secret, all we can say is that his imagination was as defective as his judgment. Similarly as regards the Eastern Telegraph Company's representative at Alexandria. It has been argued that he knew, or ought to have known, that a Press message was being sent through one of the company's cables, and that he ought, therefore, to have refrained from sending any news over the second cable lest the news going over the other should be anticipated. That argument would apply equally to any private individual in Alexandria where the news was published in the streets; and we are landed at the preposterous conclusion that no matter what number of cables were available, or how wide soever the news might be known, everything was to be kept idle in order that Mr. Burleigh's telegram might arrive at its destination first. We should like to have the opinion of the Post Office authorities on this point of telegraphic ethics. Suppose, for example, the first "result" of the Derby—which after all is not a contest of such national importance as a battle in which English troops are engaged—were handed in on a form containing four or five hundred words. Would it be the first to arrive in Fleet-street? We suspect not. But be that as it may it is plain that, although under no circumstances can the war telegram of a newspaper correspondent passing over military wires be considered inviolable, the particular telegram in question would have beaten its competitors had it been brief. There is far too much disposition on the part of newspaper correspondents to treat the telegraph as if it were a racecourse; but if they expect to win they should at least take care not to handicap their horses too heavily. The further question whether the agents of a telegraph company may join in the race is one for their consideration alone. They may do so on public grounds or for private reasons of their own; but whatever their reasons, so long as they do not appropriate it directly from what is exclusively passing over their lines, they are perfectly within their rights to transmit public news on their own account.

CORRESPONDENCE.

OVERHEAD TELEGRAPH AND TELEPHONE WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The correspondence now being published in your paper between "Mos Legem Regit" and "Telephonist" is of great interest to anybody practically acquainted with the London Exchange system. "Mos Legem Regit" says in his last: "In some of the earlier London Exchanges there appears good evidence of careful design to prevent the effects of induction, because the wires were carefully separated all the way to the switch-boards. On the other hand, the wires leading into the more recent exchanges are tied closely together in bundles, although the insulation on the wires is less adapted to resist damp. Nothing but some half-fledged theory can have originated this bold and reckless deviation from the former practice."

Well, what *can* you expect from half-fledged electricians but half-fledged theories? The men who designed the earlier exchanges *were* electricians and engineers, not of the class which the low salaries of the company now buy into their service. The primary reason for making the wires into bundles and jamming them into troughs was that in the old system the wires being strained on cleats about half an inch from the ceiling they became so coated with dust as to be twice their natural size, so that on the room shaking or the least wind the dust used to come down in clouds on the heads of the lady operators, much to their disgust. The secondary, or what should be a secondary, reason with a rich company was the cost of putting them up.

But somehow or other no one thought of cleaning them; in fact, they were not dusted more than once or twice from the time the company united until they were taken down, which was about a year ago.

Then as to induction. Is a waterpipe earth connection good enough for an exchange of 500 subscribers? In fact, in some of the subscribers' offices the connections are simply disgraceful, the wires being merely trussed together without the least attempt at a soldered joint.

I am inclined to think that a good deal of this so-called induction is greatly due to bad earth.

In one case, in one of the City call rooms, there used to be four instruments in communication with four different exchanges. Two of these lines were run together in a cable along with several others for some distance, then separated; the other two ran in a totally different direction not only to themselves but to the other two, and yet conversation was quite audible between any two lines. Surely this was not induction.

Then there is a great deal of unnecessary talking on trunk lines, owing to so many different systems being in operation in the several exchanges, which greatly adds to the Babel.

But while outsiders are trying to ferret out the mysteries of induction, what is the company doing to lessen the effects? Practically nothing, in a scientific way. The least they might do is to separate their trunk lines from subscribers' lines, and pay a little more attention to the insulation of them, as the effects of induction are always felt more on trunk lines than any others, they being the longest, as there are very few lines of any great length belonging to subscribers. These and many other faults, which are nothing in themselves, when blended together go to make up this *bête noire*—induction.

Referring to the above remarks about half-fledged electricians, these would hardly apply to the outside staff, as this is quite distinct from the indoor work, and is composed of engineers of standing, although the arrangements between the two are so complicated as to throw a good deal of the blame of the one on to the other.—Yours, &c.,

EXPERIENTIA DOCET.

London, May 7, 1884.

RAILWAY AND ELECTRIC APPLIANCES COMPANY (LIMITED).

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Every effort has been made to cause it to appear that I have endeavoured abusively and without reason to call in question the actions of some of the principal persons connected with the company, and furthermore that my object in doing so was entirely selfish and antagonistic to the interests of the shareholders.

In answer to all such attacks—and I submit that my object is to save my own property, which is represented by shares, and is therefore of exactly the same character as that of every other shareholder who occupies an independent position, and is not liable for irregularities personally or through his colleagues' insinuations—I will place at the disposal of the shareholders of the company, and invite their most thorough examination and criticism, the evidence which has forced me, in the protection of my own interests (which are solely represented by shares, and in common with other shareholders) to oppose the so-called "terms of compromise," which I do not hesitate (without fear of proof to the contrary) to condemn as exclusively individual interests and in every way prejudicial to the shareholders of the company.

Some of those who were mainly instrumental in promoting the company have introduced themselves into the management of the company's affairs, and the printing press has been freely used to make it appear that the terms of compromise are beneficial to the company.

Intermediaries came forward at the moment when the

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directors, who had brought action against the promoters, found themselves saddled with the costs of the petition for liquidation.

These intermediaries are the intimate friends and colleagues of those who promoted the company, and if testimony sworn to by the friends of the Duke of Manchester and the London directors is of value, they are not only to be beneficially interested in the terms of compromise, but have much to fear if that compromise is rejected, and the just claims of the shareholders are enforced.

I submit that facts such as these constitute a grave *primâ facie* case against the disinterestedness of those by whom this proposed compromise has been arranged, and when it is remembered that at the recent meeting *absolutely no attempt was made to disprove such facts by the offer of any counter evidence,* their importance may be fully estimated.

It is worthy of the shareholders' most serious consideration that not one of the statements made in the pamphlet and circulars with reference to the conduct of some of the directors, the promoters, and others associated with them in the company's affairs has been refuted, nor has there been any attempt made at an answer.

These gentlemen have contented themselves with vague and entirely unsupported denials of the accuracy of some of the statements, and instead of endeavouring to satisfy the shareholders, in whose names they are supposed to act, they have resorted to the feeble and miserable device of evading facts with personal abuse and insinuations without even having truth as a base.

The speeches of Colonel Jackson and Mr. W. A. Smith at the meeting on the 18th April were confined to characterising the circulars and pamphlets as "amusing documents" and "very abusive to a plausible but disingenuous criticism of the balance-sheet"—which, however, was denominated "a mass of absurdities"—and to an attack on my motive by means of the improper use of a private letter and by some false statements about my connection with the Williams Company. These things I shall deal with in their place, but before noticing what is personal I shall call attention to what concerns the shareholders, in order to expose Colonel Jackson's attempt to divert their attention by mere side issues from what is of vital importance.

The shareholders must not be cajoled by any of the inspired notices which have appeared in some newspapers into the belief that Colonel Jackson's policy has carried the day. On the contrary, two very important obstacles prevent this, viz., first, the required majority of votes was not obtained to sanction the alterations in the Articles of Association, without which the directors are powerless to carry through the terms of compromise; and second, at present an interim injunction exists in the Court of Chancery restraining them from using the assets of the company in the way proposed under the said "terms of compromise of litigation."

It is to be hoped that the shareholders will adopt vigorous measures to protect their rights and property, and it is in order to aid them in this direction that I again call their attention to the facts of the case as already laid before them in the circulars and pamphlet regarding—

1. The promotion of the company, with its attendant irregularities.

2. The existence and management of opposition companies by some of the directors and promoters of this company.

3. The character of the arrangement with the National Electric Company.

4. The questionable use of some of the shares of this company.

5. The position of Mr. W. A. Smith and others in connection with the affairs of the company.

6. The claims of the shareholders against those who have caused them loss.

7. The irregularity of the meeting in August, 1883, and the character of the committee since acting.

8. The beneficial effects of the proposed compromise to the promoters and their friends, and this regardless of the future of the company or the cost to the shareholders or their rights.

9. The disastrous loss of £55,000 which the shareholders must sustain if the terms of compromise proposed by the directors are recognised by the shareholders.

10. The value of the railway patents and other assets possessed by the company.

All the statements in the pamphlet and circulars bearing on these matters may be held as established facts, as they are unanswered. Col. Jackson's only argument in favour of the compromise was that it would reduce the nominal capital of the company, and would prevent the expenditure of money in litigation. I repeat that this argument is utterly fallacious, because it does not tell the whole truth, for he omits to mention that *along with the extinction of the capital in this way goes necessarily the extinction of the very assets which the company was formed to acquire and work.*

The statement about expenditure of money in litigation is no more trustworthy, because it conceals the fact that if it is the litigation against promoters and others which is meant, the shareholders are pretty certain to recover their costs and something more from it; while if it is the litigation with the dissentient shareholders which is alluded to, the surest way to lose costs, as well as the whole amount involved in these actions, is by adopting Col. Jackson's policy, which is solely beneficial to others than the general body of shareholders. I do not deny that it would be a good thing to reduce the share capital of the company by the extinction of £50,000 of fully paid shares, but I maintain that *this should be and can be done without parting with the property of the company.*

In this case there would be "assets" in existence which would be "freed from a very heavy charge" upon them, and there could be "profits" upon which a reduced capital would be "entitled to claim."

In any other view the arguments and policy advanced and advocated by Colonel Jackson are entirely delusive, and the fact that the compromise means plainly a direct loss to the shareholders of £55,000, besides the entire liberation of those who are at present claimed to be liable to the shareholders for loss and damage, is enough to prove that the scheme of compromise as advocated by Colonel Jackson is, from the shareholders' point of view, more than "a mass of absurdities." It is to be hoped that Colonel Jackson and his friends are not deceived into supposing that such an arrangement can be allowed.

As to my balance-sheet, which shows the results to the shareholders by rejecting the terms of compromise and realising the just claims of the shareholders, Colonel Jackson has announced that the Williams Company is without capital, and is in liquidation, and he unhesitatingly affirms that it would not only be "very difficult" to get £29,500 from a company in this position, but also that "it is important to know that £29,500 cannot be got out of the Williams Company. But does not Colonel Jackson himself propose to get £24,000 out of that company under the "terms of compromise of litigation?" How then does he expect to get this amount from a company which has no capital and is in liquidation? Are we to apply his own argument to himself, and assume that after all the terms of compromise "are only a sham?" The truth is that he knows well where the £24,000 of the £29,500 referred to in my statement is to come from, and as to the balance he knows also that the liquidator of the Williams Company retains in his own hands £5,000 more, which was received from the Railway and Electric and Appliance Company, particulars of which he did not expose at the meeting. It is therefore evident that the assets of the Williams Company are good for £29,500, the amount named in my balance-sheet as recoverable from it. Col. Jackson also stated that the National Company has only "£8,000 or £9,000 of capital left," or, in other words, that the capital of this company is only £1,000 or £2,000 more than the sum it received in cash from the Railway and Electric Appliances Company, and he calls upon me to "explain how £22,000 are to be got out of a company that has only £9,000."
I therefore submit Col. Jackson has omitted to notice that

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under the "terms of compromise" he credits that company with assets sufficient to purchase £15,000 worth of property from the Appliances Company, and as he admits the existence of other £9,000, it is evident that in criticising adversely my balance-sheet Col. Jackson misrepresents the true state of that company's affairs.

Col. Jackson does not agree with me as to the possibility of recovering damages from the promoters and others. He could not be expected to accept my view readily under the circumstances, but I confidently submit, if the shareholders of the company will take in hand the management of their own affairs, the force of circumstances may be found sufficient to induce a material change of views in Col. Jackson, and probably in others also.

In presence of such facts as are at the command of the shareholders it is not difficult to enforce a recognition of their just claims, and prevent the loss of £55,000, which would be the result under the proposed terms of compromise.

This is a case not without precedent, as must be well known by some of the directors, and therefore the solemn warning of Col. Jackson about "ruinous costs" and "loss of assets" is the mere conjuring up of a spectre to terrify the shareholders. Why he should bring in "loss of assets" in *this* connection it is difficult to imagine, because that is exactly the result of the compromise which he so ardently advocates. Even failure in these actions will be no worse than the results from carrying out the terms of compromise.

Col. Jackson prophesied boastfully that failure would be the result of "the attempt" to set aside the terms of compromise, and he announced in the same spirit that the number of proxies held by the directors was sufficient to "outvote and checkmate the attempt to govern the affairs of the company" in a way which he considered as likely to be to its detriment. It is therefore fair to analyse the measures adopted to secure the fulfilment of Col. Jackson's predictions.

It appears from the poll that the total number of shares voted in support of the "terms of compromise" was 57,917, but of these 40,450 are the very shares which in their report the directors told the shareholders had been assigned to Col. Elliot and Col. Jackson in trust for the company. I submit that such shares held in trust for the benefit of the company should not be used against the shareholders of the company; but Col. Jackson did not hesitate to employ them, and solely by their use to secure his seat upon the Board and to prevent the removal of Mr. Smith, and to carry the terms of settlement with his friends which are disastrous to the shareholders, although Col. Jackson had previously denounced these shares as "an incubus" and as "that element which presses most against the interest" of the capital of the company. He did not scruple to urge that the possession of fully paid up shares and the voting of them by others was directly antagonistic to the interests of the shareholders, and yet he is found using shares obtained in the promotion of the company, and by such means only is it possible for him to swamp the shareholders holding ordinary shares who oppose his policy. He may urge that some ordinary shares are also found in the majority. That is true; but of these ordinary shares so voting 11,644 were held by the vendors and promoters, and those especially connected with them, while 3,700 more were held by the directors and their relations. If these numbers are added together and subtracted from the total number voted in favour of the compromise resolutions there will appear 2,123 as the number of presumably independent shares voted for these resolutions, but in this number is included probably the shares of Mr. Arrol, one of the directors.

This result shows conclusively that outside of those who were directly concerned from personal and pecuniary reasons the general body of shareholders gave no support to the policy which sacrifices both their property and their just rights.

Even if we allow that the number 2,123 given above is entirely made up of independent ordinary shares, the number of such shares voted against the resolutions is much in excess of those held by the directors.

The total of 25,216 voted against the resolutions contains my fully paid shares, and shareholders who could not be present trusted to the weight of these being used in their interests. All that Col. Jackson can urge or has urged against these shares being regarded as identified with the shareholders' interests is that they are fully paid, or, in other words, that I am not subject to calls which the directors cannot under these proceedings long avoid, and that I personally do not care for the shareholders' interests, but only to make money for myself at their cost. These statements or insinuations are characteristic of the tactics resorted to by Col. Jackson in his efforts to effect a compromise so beneficial to his allies and so disastrous to the shareholders, of which I am one.

The evidence given in my pamphlet of the value of the railway patents, some of which I in part conveyed and some of which I wholly conveyed to the Appliances Company, is incontestable, and it was endorsed, if that is of any importance, by Mr. Smith at the meeting on the 18th inst. I submit that I conveyed property of value to the company in exchange for shares, and unless these shares are made valuable by the proper administration of the company's affairs I shall have given my property and received worthless paper. I submit that I am exactly on the same level and in the same category as those who have given money for their share certificates.

But both Col. Jackson and Mr. W. A. Smith insinuate that I have already received £20,000 in cash and £20,000 in shares from the Williams Company for these same inventions (which shares I hold). This is untrue, and Mr. Smith adds that having obtained my money from that company I "left it in the lurch" (which is also untrue), thus insinuating that I caused it not to succeed. This insinuation has expanded possibly under influence or inspiration so as to appear in a paper as a bold declaration that I endeavoured "to wreck the company," and this paper is the one which has been selected by the directors as the vehicle between them and the shareholders; but the persons responsible for the libel will meet with punishment in the proper quarter.

The £17,500 of shares I received from the Appliances Company represents the shares and the interest I possessed in the Williams Company and the further railway patents conveyed by me direct to the Appliances Company, and I transferred to the Williams Company the £17,500 of shares I held in that company.

I submit in contradistinction to Mr. Smith's statement that I expended several thousand pounds in prosecuting and pushing the business of the Williams Company after its formation, supplied the company at my own cost for some years with almost every illustration of the appliances which it possessed, and with nearly every model, and lent the company considerable sums, from which I did not derive one penny of advantage, and ever since the Railway and Electric Appliances Company acquired these patents I have spent considerable sums in the preparation of plans and documents and in personal endeavours to carry through the contract with the Wemyss Bay Railway Company. These efforts would have been successful long ago had I not been persistently met and hindered by conduct of the most unsatisfactory character on the part of those managing the affairs of the company.

I have only yet to refer to the private letter to Mr. J. E. Watson, which Col. Jackson, without explanation or apology, read at the meeting in order to make it appear that my motives were antagonistic to the shareholders.

As to my object, it must be evident that if I did not hold shares in the company I would not have any interest or right to oppose, but believing as I do that the policy of the directors is bad, and that the terms of compromise are not only absurd but ruinous to the shareholders, I as a shareholder preferred to retire from the company in preference to remaining as a shareholder if the assets of the company are to be squandered as under the proposed terms of compromise.

But as I have unwillingly been forced to expend time and money to protect my shareholding, and have received the votes of others in opposing the ruinous policy of the directors, my position to-day is different from when I wrote the referred-to letter, and I am fully convinced that the directors have not the power to compromise the actions of the serious character which they themselves instituted.—Yours, &c.,

JOS. S. WILLIAMS.

London, May 9, 1884.

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THE DIAMETER OF CONDUCTORS TO PREVENT OVERHEATING IN ELECTRIC CURRENTS.*

BY PROFESSOR GEORGE FORBES.

The heating of conductors by the passage of an electric current is injurious to the insulation if the conductor be insulated, and may lead to risks from fire.

In small installations the heating of conductors is always small, because of this fact—that if contractors were to lay down wires so thin that overheating ensued then we may be sure that the resistance would be far too great for the capabilities of the dynamo machine.

But in large installations, currents of much greater density being carried, the heating may be very great, although the resistance of the circuit is small; and it becomes a matter of the utmost importance to know how the heating depends upon the size of conductors and the current density.

I have searched in vain for experimental facts on a large scale, and in absence of these have undertaken the mathematical solution of the problem, and confirmed my results by a few experiments on small currents, besides such isolated examples of measurements of large currents as were available.

I have been at some trouble to determine carefully the nature of conductors which would be required to carry a current capable of supplying 100,000 lamps—say, 70,000 amperes. It may be said that no such conductor would be required—that electricity will be so carried in a network of conductors that in no part will the current carried be excessive. It may further be said that high tension currents will be used to charge accumulators in series, scattered here and there over a district, and that, consequently, small currents only will be required in the mains. To the latter objection I say, that to carry out some of the provisional orders granted by the Board of Trade, the system of secondary batteries being inadmissible, it will be necessary to carry through the mains current sufficient for all the lamps. To the former objection I say that the supply of gas gives us a valuable insight into the similar progress which must be made in the supply of electricity. The problems are remarkably similar, and a due attention to this fact will save the pioneers of electricity much useless expenditure of time, money, and thought. But in gas lighting we carry enormous mains for distances of many miles from the place of manufacture. Witness the huge 4ft. pipes laid through this district last year to carry gas from Wandsworth to the City. There is no network of conductors here; it is found necessary to carry in one main gas enough to supply hundreds of thousands of gas lamps. Let it be well noticed, also, that it would be possible to force the gas at high pressure through narrow tubes to fill and supply gasholders spread about in different parts of a district. The analogy to the proposed system of charging accumulators at high tension is perfect, and this leads me to doubt very much whether the system which has not been found advisable with gas is likely to be successful with electricity.

I still maintain that to supply the electric light on a large scale we must face the problem of finding out what conductor will carry a current of 70,000 amperes without overheating.

Now, in doing this we are going a step in advance of what has been done before, just as (to cite, as example, a contemporary engineering work), in designing the Forth Bridge, Messrs. Fowler and Baker are extending the principles of bridge-making to magnitudes hitherto unknown. Here the laws of the stability of bridges are known, and, with experience on smaller bridges, combined with laboratory tests of the strength of materials, a sure advance can be made to the larger structure. It has been my endeavour to find out whether, with the facts at our disposal as to the smaller currents carried by smaller conductors, and the laboratory experiments on the nature of our conductors and insulators, we are in a position to propound laws which shall be a guide to us in extending these principles to the construction of a suitable conductor for very large currents, say of 70,000 amperes.

* Paper read before the Society of Telegraph Engineers and Electricians.

In 1882 the Fire Risks Committee of this society discussed the question, and I believe I am right when I state that it was seriously proposed as a rule, to prevent overheating of the wires, that the permissible current should be so many amperes per square inch section. I have often heard this error repeated. I believe it has actually been adopted by the fire insurance companies as a measure of safety, and a precise 1,000 amperes per square inch has been given as the safe current. With regard to the insurance companies, little harm has been done by this, because they have had only small installations to deal with at present, and, as above stated, there is practically no danger from this cause; but it seems surprising that in one breath they should tell contractors that in small installations they must not raise the temperature of their conductors $\frac{1}{10}$ of a degree, and that in large installations they may make their conductors red-hot.

As a matter of fact, in any installations, except very large ones, the safe conductor ensures greater economy than the unsafe one; and Sir William Thomson has done well* in fixing the size of conductors by commercial considerations when he showed that the interest and depreciation on the cost of conductors should equal the annual loss of horse-power in heating up these conductors.

There is a limit above which this rule does not apply, because the heating becomes so great that the insulation is injured. The first person who, so far as I know, has taken notice of this is Mr. Cowling Welsch, in a table published by Messrs. E. and F. Spon. He fixes the limit at 2,700 amperes, but he does not state what he considers to be the limiting temperature which is tolerable, nor does he specify the nature of the insulation. His facts seem to be taken from the tests of Messrs. Clark, Forde, and Taylor (see below). Mr. A. Gray has also taken notice of the failure of Sir William Thomson's law for high currents, in a paper contributed to the *Philosophical Magazine* in 1883, and fixes the limiting value at 5,000 amperes.

I shall not take up the question of how Sir Wm. Thomson's rule is to be applied commercially. I have resolved in this communication to confine myself to one point—the strength of current which can be carried through a wire under different conditions without overheating.

I find that two writers have worked at this subject from a mathematical point of view, and each has worked out some concrete examples. One of these is Mr. Day, of King's College, whose useful little book, "Electric Light Arithmetic," should be studied by all learners. The other author is Mr. A. Gray, formerly a pupil of my own, now Sir William Thomson's assistant. His remarks on the subject appear in the *Philosophical Magazine*, September, 1883. In discussing the question of bare wires both of these authors assume that the cooling effect is proportional to the surface, and they make no reference to the variation from this law which I pointed out in 1882 to the British Association, and which has been confirmed by Mr. Preece. Mr. Day deals only with the case of naked wire, in which he arrives at the theoretical law—(currrent)^2 $\propto$ (diameter)^3—which I published in 1882, but which I also showed at that time to be contradicted by experiments on a small scale. My own view of the matter is, that while of course radiation is proportional to surface, convection is not so, but is nearly constant for rectilinear wires of different diameters but the same temperatures, and that with thin wires consequently convection is the most important factor, but for thick wires radiation proportional to surface is the ruling factor; hence the tables which I have computed are correct for large diameters, but with small wires greater currents may be safely carried.

Mr. Gray has also gone partially into the theory of an insulated cable, and arrived at formulæ very similar to my own.

Some experiments were made by Messrs. Clark, Forde, and Taylor for the Indian and Oriental Electrical Storage and Works Company in the last year or two, and the results are published in *The Electrician* for April, 1883. The general conclusion arrived at is, that up to 10 amperes it is safe to allow 1 ampere per 10 pounds of copper per mile, either with naked

* B. A. *Reports*, 1881.

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TABLE I.

Bare Copper Wires.—Current required to increase the temperature of a copper wire t° centigrade above the surrounding air, the copper wire being bright polished or blackened.

Diameter in centimetres and mills. (thousandths of an inch).		CURRENTS IN AMPERES.									
		$t=1°$ C.		$t=9°$ C.		$t=25°$ C.		$t=49°$ C.		$t=81°$ C.	
Cm.	Mills.	Bright.	Black.	Bright.	Black.	Bright.	Black.	Bright.	Black.	Bright.	Black.
·1	40	1·0	1·4	3·0	4·1	4·8	6·6	6·5	8·9	7·9	11·0
·2	80	2·8	3·9	8·3	11·5	13·5	18·7	18·3	25·3	22·4	31·0
·3	120	5·2	7·2	15·3	21·2	24·9	34·4	33·5	46·4	41·2	57·0
·4	160	8·0	11·0	23·6	32·7	38·3	53·0	51·7	71·5	63·4	87·8
·5	200	11·1	15·4	33·0	45·7	53·5	74·1	72·2	99·9	88·6	123
·6	240	14·6	20·3	43·4	60·0	70·3	97·4	94·9	131	116	161
·7	280	18·5	25·6	54·6	75·6	88·7	123	119	165	147	203
·8	310	22·6	31·2	66·7	92·4	108	150	146	202	179	248
·9	350	26·9	37·3	79·6	110	129	179	174	241	214	296
1·0	390	31·5	43·6	93·3	129	151	210	204	283	251	347
2·0	790	89·2	123	264	365	428	593	577	799	709	981
3·0	1180	164	227	485	671	787	1090	1061	1468	1303	1805
4·0	1570	252	349	746	1035	1211	1675	1633	2260	2006	2776
5·0	1970	353	488	1043	1444	1692	2343	2283	3160	2802	3880
6·0	2360	463	642	1371	1898	2225	3080	3000	4154	3685	5100
7·0	2760	584	808	1728	2392	2803	3882	3781	5233	4642	6426
8·0	3150	714	988	2110	2922	3422	4741	4620	6396	5671	7850
9·0	3540	851	1178	2519	3486	4088	5659	5511	7630	6769	9370
10·0	3940	997	1380	2950	4084	4788	6626	6455	8935	7926	10973
34·4	...	...	...	...	...	...	...	...	...	...	70000

wire or with insulated wires buried in sand, in the hot Indian climate. They furnish the following table :—

CLARK, FORDE, and TAYLOR'S TABLE.

B.W.G.	Diam. Mills.	Weight in lbs. per mile.	Amperes.	Lbs. per ampere.
22	28	12·4	2·33	5·32
21	32	16·2	2·84	5·70
20	35	19·5	3·27	6·20
19	42	28·0	4·3	6·5
18	49	38·1	5·4	7·0
17	58	53·3	6·9	7·7
16	65	67·1	8·3	8·1
15	72	82·5	9·6	8·6
14	83	109·5	11·9	9·1
13	95	143·0	14·56	10·0

No information is given as to the temperature which is considered permissible.

In the second supplement of *The Electrician*, published in March, 1883, a table was printed, supposed to give the currents which could be safely worked through different thicknesses of conductor. This table, however, was founded upon the assumption that the safe-working current was proportional to the sectional area, which is now well known to be far from the case. I quote this simply as one example, out of many which have come to my notice, of the same mistake being made by people who ought to be better informed. Mr. Jamieson has given a similar rule of 1,000 amperes per square inch for small installations, with an insulation resistance for the whole circuit of not less than 1,000 ohms per volt of E.M.F. generated by the dynamo. As I have said, the question of safety does not arise in choosing the diameter of wire for a small installation.

There are five primary cases of conductors which must be treated separately—(1) Overhead naked wires; (2) Overhead cables; (3) Subaqueous cables ; (4) Subterranean and embedded cables; (5) Coils.

I have added the fifth case, of coils, because it is important in the manufacture of dynamos and magnets.

Each of these classes has its own peculiarities. In all of them heat is generated by the current, and this heat must be got rid of. In case (1) it is got rid of solely by radiation and convection; in the others partly by conduction, and in case (4) very largely by absorption. In case (1) the maximum temperature is reached almost immediately; in some of the other cases it may be many hours before the final steady flow of heat sets in.

Having convinced myself that the most satisfactory mode of attacking the problem was to treat it in a strict mathematical way, and being well aware that all the requisite data had been obtained by previous experimenters, I determined to work out practicable tables for the use of electricians from these data, including both bare and insulated conductors. The first step was to solve the following problem :—

PROBLEM I.—*To find the law connecting diameter*, D, *of conductor with that strength of current*, C, *which raises its temperature by a fixed amount t° cent. above that of the surrounding air.*

Let R = the resistance in ohms of a cubic centimetre of the substance of the conductor (= its specific resistance).

Let E = the heat radiated per second from a square centimetre surface when the temperature of the surface is 1° cent. above that of the surrounding air.

The radiation from the surface of 1 cm. length of the wire is $\pi D t E$, and this must equal the heat generated in 1 cm. length of the substance $= C^2 \cdot \dfrac{R}{\pi \left(\dfrac{D}{2}\right)^2} \times$ (number of units of heat in 1 watt) $= C^2 \cdot \dfrac{4R}{\pi D^2} \times \cdot 24$.*

Whence
$$\pi D t E = C^2 \frac{4R \times \cdot 24}{\pi D^2},$$

and
$$C^2 = D^3 t \cdot \frac{\pi^2 E}{R \times 4 \times \cdot 24} \quad \ldots \ldots \quad (a)$$

This shows that if the heat be lost by radiation, or by any means which is proportional to the surface, then, in order to keep all the wires of different diameters at the same temperature, we must have the cubes of these diameters proportional to the squares of the currents if the change of resistance with temperature be neglected.

Example :—To take, as a special example, the case of copper, we know that

$$R = \cdot 000001642 \text{ ohm}\dagger \text{ at } 0° \text{ centigrade,}$$

* Everett's "Units and Physical Constants." Joule's equivalent of a Gramme centigrade heat unit = $4 \cdot 2 \times 10^7$ ergs, and one watt = 10^7 ergs, ∴ ·24 = number of heat units in one watt.

† Maxwell's "Electricity and Magnetism," Vol. I., last chapter.

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and increases ·38 per cent. per degree centigrade;

$$E = \cdot 000168 \text{ (polished), or } \cdot 000300 \text{ (blackened).*}$$

To take an example, let $C = 10$ amperes; let the wire be No. 16 B.W.G. $= 0{\cdot}165$ cm.; the rise of temperature comes out $t = 21{\cdot}2°$ C., polished, or $t = 15{\cdot}0°$ C., blackened.

This table is calculated from the formula

$$C^2 = D^3\, t \cdot \frac{\pi^2 E}{4\,R \times 0{\cdot}24}$$

C = current (amperes).
D = diameter of wire (centimetres).
t = excess of temperature (centigrade) above air.
E = coefficient of radiation and convection.
R = specific electrical resistance (ohms).
$\cdot 24$ = number of gramme-centigrade heat units in a watt.

Temperature of the air assumed 20° C.

$$R = 0{\cdot}000001642\left(1 + \frac{\cdot 38t}{100}\right).$$

$E = \cdot 000168$ for polished, $\cdot 00032$ for bright, copper.

The accompanying Table I. has been computed from the formula obtained above. It gives the rise in temperature in bare copper wires with different currents.

(TO BE CONTINUED.)

* This is taken from D. M'Farlane's experiments (*Proceedings* Royal Society, Edinburgh, 1872, p. 93), in which radiation took place from balls of considerable size, and consequently convection played an unimportant part. If the rise in temperature were 100° or more, it would become necessary to take account of M'Farlane's second and even third terms, depending on t^2 and t^3.

LITERATURE.

A History of Electric Telegraphy to the Year 1837, *chiefly Compiled from Original Sources and hitherto unpublished Documents.* By J. J. FAHIE. Illustrated. [E. and F. N. Spon. 1884.]

We enter upon the notice of this work with feelings of a very mixed character. Mr. Fahie, in his preface, calls attention to our share in the matter of assisting him to put his work before the world. That our correspondence with Mr. Fahie in far-off Persia did not end so satisfactorily as a personal interview is hardly a matter for wonder. In the one case he described his work; in the other he placed the MSS. before our eyes. Our readers will no doubt agree that such an interesting history ought not to be lost. It cannot now suffer the fate of the history of the old castles referred to in the preface. We, perhaps more than others, know the difficulties under which Mr. Fahie has worked. In Persia, as he says, books are at a discount. There he had few facilities for research, and it is a wonder that, even with his inexhaustible energy, such a mass of material could have been collected. After fifteen years' absence he came home, ostensibly for a holiday, and spent that holiday in continuous work. He ransacked libraries, paid visits to those whom he thought might give information, and wrote letters all round in order to obtain the fullest and most accurate details of all that pertained to the history of telegraphy. It goes almost without saying that his whole heart was in the work. This cannot be shown better than in the manner in which he obtained the details of Davy's work after once the clue was in hands. Then his great desire was to see Davy's claims publicly recognised. He thought, and justly so, that Davy's work should stand at least upon as high a pedestal as that of Cooke and Wheatstone. There is no doubt the supineness of the Society of Telegraph Engineers was a great blow to Mr. Fahie. He hoped to see the society representing telegraphy and telegraphists enter with some of his own enthusiasm into the question of Davy's position in the annals of telegraphic enterprise.

The work of Mr. Fahie would be extremely valuable, even if it contained nothing else, for the exposition of Davy's claims. We agree with Mr. Fahie that if honour is due to Davy it should be given now while he is living. What is the use of the tardy acknowledgment of a man's claims if he is dead? We are, however, diverging from our immediate object, viz., the bringing of this book to the notice of our readers. It is one well suited to every library, filling a void in telegraphic literature, altogether of a non-technical character, and as interesting to the non-mathematician as to the mathematician. The general idea of "electrical" books is that they are books through which a host of more or less unintelligible formulæ are scattered. Here is one, however, purely historical—one that can be appreciated by all readers. The information it contains has been collected with much labour, and verified with great care, and is such as should appeal to every member of the profession. We ought to be very jealous to see due credit given to every pioneer in the great work of introducing telegraphy, and if we err at all it should be on the side of being too generous.

Mr. Fahie, in the first place, shows the foreshadowing of the electric telegraph, then deals with static electricity and the telegraphs based upon static electricity, this being followed by a similar disquisition in dynamic electricity and apparatus based thereon. Electro-magnetism and electro-magnetic instruments then claim attention, bringing us to the work of Davy. The index to the work has been prepared by Mr. A. J. Frost. We have done but scant justice to this book, both book and author deserving all the praise we can give them.

A Concise Treatise on the Law and Practice of Patents for Inventions, consisting of the Patents, Designs, and Trade Marks Act, 1883. The New Rules and Numerous Notes and Cases by CLEMENT HIGGINS, Barrister-at-Law. [William Clowes and Sons. 1884.]

Handbook to the Patents, Designs, and Trade Marks Act, 1883. Containing the Act and Rules. Also an explanatory and Practical Treatise thereon, and the Procedure thereunder, for the use of Inventors, Manufacturers, &c. G. BRISTOW HUNT. [Waterlow and Sons. 1884.]

These works differ from each other, and from that of Messrs. Clark referred to in a previous notice, though treating of patents, &c. The former of the two now mentioned is written more from the legal standpoint; the latter is both legal and practical. Both have their good points and their particular uses. The one will most probably be referred to when the question to be decided is a legal one; the other is more for general reference. Mr. Higgins gives a fairly complete table of cases and a good index, valuable parts of such works as this. In fact, all the books are good in respect to indexing.

A Bibliography of Electricity and Magnetism, 1860 to 1883, with special reference to Electro-Technics. Compiled by G. MAY, with an Index by O. SALLE, Ph. D. [London: Trübner and Co. Vienna: Hartleben. 1884.]

This book partakes of the nature of a bookseller's catalogue of the books and pamphlets on electrical subjects issued between 1860 and 1883. It shows that the literature of the subject is enormous, and the wonder is when the supply will diminish.

MAGNETISM AND ELECTRICITY.

BY CHARLES F. CHANDLER, PH.D., PROFESSOR OF CHEMISTRY AND MEDICAL JURISPRUDENCE.

[We reproduce the following lecture in answer to a frequently-repeated demand for elementary information, in a condensed and popular form, such as might be available to those who, without having the time or the desire for scientific study, are inclined to take a practical interest in some of the applications of electricity. The American professor has certainly succeeded in compressing within narrow limits a considerable amount of knowledge, which, being expressed in familiar language, may be acceptable to the class to which we have referred. At the same time, although allowance should be made for the conciseness aimed at and realised by the writer, there are some statements in his paper which are open to objection, and which we may leave for the present to the

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criticism of students who in this country have had impressed upon them views adverse to the statements in question.]

Magnetism.

I will say only a word about magnetism. A magnet is either natural or artificial. A natural magnet is a piece of magnetic iron ore or magnetic oxide of iron (Fe_3O_4), also called loadstone, and it occurs in nature. An artificial magnet is one produced by artificial means. Artificial magnets are of two kinds—permanent and temporary. A permanent magnet is a piece of steel that has been magnetised by bringing it in contact with another magnet or piece of loadstone, or by passing a strong current of electricity around it. A temporary magnet is a piece of soft iron which has been made temporarily magnetic by being brought near to a permanent magnet, or by passing a current of electricity through a coil of wire surrounding it. The properties of a magnet are :—1. The power of attracting certain metals—iron, nickel, cobalt, and, to a slight degree, chromium, and a few others. 2. The property of tending to assume a certain position as regards north and south. A magnetic bar or needle, if allowed to hang by its centre on a string, or to float free on a piece of wood in water, will assume a position approximating north and south, but not exactly so. 3. The property of polarity—that is to say, a magnet—exhibits its peculiar attracting powers chiefly at the extremities. There is a centre of attracting power near each end, but not absolutely at the end, and at this point or centre the magnetic power is strongest. These two magnetic centres are called the poles of the magnet ; the end which points toward the north is called the north pole, and the one pointing toward the south the south pole of the magnet. When two magnets are brought near each other, the north pole of one will attract the south pole of the other, and repel the north pole. So it has been found to be a law with magnets that "like poles repel, and unlike poles attract each other."

With regard to the direction the magnetic needle takes when allowed to move freely, it does not point directly north and south, but it assumes a position pointing a little to the east or to the west of north and south, depending upon the locality at which the observation is made. This is because the magnetic poles in different parts of the earth do not correspond exactly with the geographical poles, and the difference between them varies with the location at which the observation is made. This is why nautical almanacs are made to tell mariners the amount of variation from the true north and south made by the compass-needle in different parts of the world. This deviation of the compass-needle from the true north and south is called the "declination" of the needle. The term "declination" is very liable to be confounded with that of "inclination." When a bar of steel is hung by a thread at its centre, it assumes an exactly horizontal position ; but if this bar of steel is now magnetised, it will assume a direction pointing north and south, but it will no longer hang exactly horizontal except at the equator of the earth.

At all points north of the equator the north pole of the bar will dip downward, and the farther north you get the greater will be the dip, while at all points south of the equator the south pole of the bar will dip downward ; and the degree to which the needle dips from the absolutely horizontal direction is called its "inclination." This is because the two magnetic poles of the earth do not correspond to the two geographical poles, but they appear to lie nearer the centre of the earth. To overcome this tendency of the magnetic needle to dip at a varying angle according to the distance north or south of the equator, the needle of the mariner's compass is made by uniting two magnetic bars laid parallel, with the north pole of one adjacent to the south pole of the other, so that they lie with their opposite poles end to end. Such a needle is said to be "static." At a point on the surface of the earth corresponding with latitude 70° N. and longitude 96° 43′ W. the north magnetic pole seems to be located, and at this place the dipping needle assumes a vertical direction. The south magnetic pole is apparently located at latitude 75° 5′ S. and longitude 154° E.

The production of magnetism by induction is a curious phenomenon. If a permanent magnet is brought near a handful of iron nails it will attract them to it, and as soon as a nail becomes attached to the magnet it becomes a magnet itself and attracts another nail, which in turn becomes a magnet and attracts another, and so on, the magnetic power of each new nail attracted becoming constantly less than that of the preceding one. It is not even necessary that the nail should absolutely touch the magnet in order to assume this magnetic power, for it will be transmitted through short spaces from one to the other. This power which a body acquires by being brought near a magnet is called "magnetic induction." An important fact in this connection is that when a coil of iron wire is made to surround a permanent magnet it becomes magnetic itself by induction, and is capable of inducing magnetism in another bar of iron surrounded by it. This principle is made practical use of in the construction of the telephone and magnetic telegraph.

Electricity.

We now come to the subject of electricity. This is a peculiar agent, capable of producing certain astonishing results. There are different forms of electricity and different ways of generating it. The different forms are statical electricity, dynamical electricity, and magnetical electricity, or magnetism. It may be generated by means of friction, percussion, heat, chemical action, cleavage, and by magnets. The effects of electricity in its different forms are manifested as attraction, repulsion, light, heat, violent commotions, and chemical decomposition.

To excite electricity we must always do something, and the first way of producing it, discovered in the earlier ages, was by rubbing amber, and so the term electricity was derived from the Greek word ἤλεκτρον, signifying amber. It was afterward found that certain other substances when rubbed assumed electrical properties, and would attract or repel other materials. This electricity produced by rubbing or friction is called statical electricity. This is a form of electricity that can be held for a considerable length of time, and hence it has received the name of stationary or statical electricity. This is the only form of electricity that we can store up and keep for a time. What is known now as the storage battery does not really store up electricity, but only energy, which can be transformed into electricity at will. So much for statical electricity.

We have a totally different kind of electricity, called dynamical electricity, or electricity in motion. This is a form of electricity that circulates only in a conductor or along a wire, and it cannot be held. It was first discovered by Galvani in experimenting on frogs' legs, and hence it is often called galvanic electricity. It is now ordinarily produced by means of galvanic batteries and dynamo machines. The third form of electricity we have already referred to incidentally as that which is induced by means of magnets, and it is therefore called magnetic electricity, or magnetism.

According to the generally accepted theory there are two so-called electrical fluids, and these two are commingled in equal proportions in all bodies; and hence all the processes for getting electricity must result in pulling these two electrical fluids apart, and in taking a portion of one away from a body. These two fluids are called one positive and the other negative electricity. It is found that when two bodies are electrified with the same kind of electricity, as both with positive or both with negative, they repel each other ; but when the two bodies are charged with opposite kinds of electricity, as one with positive and the other with negative, or when one body is charged with either kind while the other is left in its normal condition, then the two bodies attract each other. Hence we derive the law which states that "bodies charged with like forms of electricity repel, and those with unlike attract." The gold-leaf and pith-ball electroscopes are constructed on this principle.

When a piece of sealing wax is rubbed it manifests electrical properties for some time, but certain other substances, like metals, for instance, after being rubbed in the same manner, show no electrical properties, and this is because the electricity easily gets away from them. Thus we find that while certain substances remain electrified for some time others

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do not, and hence these bodies are named conductors and non-conductors. But these terms are not absolute, but only comparative. The metals, carbon, gypsum, and acids are called good conductors, while amber, glass, sulphur, and silk are poor conductors. If we want to insulate electricity, and keep it from running off into surrounding objects, we surround the object containing it with a poor conductor. Thus, the glass insulators on telegraph poles prevent the electricity from leaving the wires and running off into the ground, and the non-conducting materials placed around the wires of the Atlantic cable so protect it that a small charge of electricity will carry a message from here to Europe.

Great difficulty is experienced in experimenting with statical electricity, because it so easily gets away. All substances are conductors to a greater or less degree, including the dust in the air and the moisture in the atmosphere. Perfect insulation and a warm, dry air are therefore favourable conditions for holding statical electricity. The reason it was not used earlier for practical purposes was because it was so difficult to manage. The electricity which is produced on glass by friction is called vitreous or positive, while that produced in the same manner on shellac or sealing wax is called resinous or negative electricity.

Franklin had a theory that there was but one electrical fluid, and that all substances in the natural state had an equal amount of it, but a body charged with an excess of this fluid was said to be in a positive state, and one in which there was a deficiency was said to be in the negative state.

But this theory has now given place to the two-fluid one, which maintains that all bodies are charged with an equal amount of the two electrical fluids called positive and negative, but when a body is electrified these two fluids are separated so that one remains in excess of the other. There is always a passage of the electrical fluid in two directions along a conductor, but, when the direction of the current is spoken of, it is the direction of the positive current that is always meant. Statical electricity can also be produced by pressure, as when certain crystals are firmly pressed together; by cleavage, as when two layers of mica are split apart; and by heat as well as by friction. It may also be produced by torsion. It is found that the charge of electricity, if collected in a spherical body, is on the outside, and not within the body; and if it is not a spherical body, the electricity collects chiefly at the part most nearly pointed. This kind of electricity is transferred in three different ways:—1. By conduction from one body to another in contact with it; 2, by convection, where gas or the air in contact with an electrical body takes away some of its electricity; 3, by discharge, where a highly electrified body suddenly loses a portion of its charge.

Electrical Machines.

Machines for producing statical electricity are usually based on the friction method. The old-fashioned machine consisted of a circular glass plate which was rotated between two cushions, and the electricity thus produced was taken off and carried to a metallic cylinder, called the prime conductor, by means of metal points. Silk and glass as insulators prevented the electricity from running off into neighbouring objects. More recently machines have been constructed on the principle of induction, as illustrated in the electrophorus. These are known as the Holtz machines.

The condensation of electricity is illustrated in the Leyden jar. This is a sort of bottle, lined up to a short distance from its top, both inside and outside, by tin foil, and in the stopper is a brass knob which is connected with the tin foil on the inside of the jar by a chain. When the knob is charged with positive electricity from a machine, it collects on the tin foil inside the jar, while a corresponding amount of negative electricity collects on the outside of the jar. By this means a large amount of electricity may be collected and held by the jar until discharged, by making connection between the tin foil on the inside and that on the outside of the jar. The electricity is held, not on the tin foil, but on the surface of the glass. This is proved by means of a jar that can be taken to pieces after being charged—although the two pieces of metal which lined the inside and outside are now brought into contact, yet when the whole is put together again the charge is found to remain, and it is discharged by connecting the knob with the metal lining of the outside. All that these metal linings accomplish here is to make a large conducting surface over the whole of the glass upon which the electricity collects.

The discharge of electricity from such a jar, or a battery of several of them connected, produces a variety of results. The spark will pass through a thin plate of glass or a card and make a hole in them by disrupting them; or, in passing through points of metal, it heats them to a high temperature and vaporises them, so that we get luminous effects from them. Electricity is estimated to travel at the rate of two hundred and eighty-eight thousand miles in a second.

Franklin first showed that lightning was simply a discharge of electricity from the clouds to the earth, and it occurred to him that, as points condense electricity and draw it away and discharge it quietly, lightning rods might be made on this principle that would prevent the disruptive effects of a discharge of lightning, and so be a protection to buildings on which they are placed. Such lightning rods are really a protection when properly made. A perfect one should be large enough to carry the charge of electricity, should have no break in it, should terminate at the top by numerous points, and connect at the bottom with the ground below the water line, and there be surrounded by fragments of iron buried in moist earth. It is well also to have it connected with the metallic water and gas pipes running through the house.

Dynamical Electricity.

Now, a few words in regard to dynamical electricity. Galvani discovered, in experimenting on frogs, that when two pieces of metal, like copper and zinc, were placed in contact with the frog's leg and their ends connected, a movement of the leg would take place. This discovery gave rise to considerable discussion and experimentation, and, as a result, Volta developed the voltaic pile, which at first consisted of alternate layers of zinc, wet paper, and copper, piled one on top of the other in varying numbers. It was found that when the top layer was connected with the bottom one by means of wires a current of electricity was set up. It became understood then that the electricity was produced by the chemical action of the water in the paper on the zinc, and so more active solvent fluids came to be used instead of water, and cloth was substituted for the paper. It was found that the zinc was the positive element here and the copper the negative, and it is usual to find in all batteries that the metal acted upon is positive, and the one not acted upon is negative. There is now, practically, only one metal used for the positive element, and that is zinc, for it is the cheapest and the best.

The Galvanic Battery.

A galvanic battery is simply a combination by which we produce this chemical action, and zinc is the metal acted upon. The principle of the galvanic battery is this: If we immerse two pieces of metal, like copper and zinc, in a liquid like sulphuric acid contained in a glass vessel, and then connect the two metals by pieces of wire, a current of electricity is set up, because the liquid is decomposed by the zinc, and the H_2SO_4 is split up into SO_4 and H_2, and the H_2 is set free while the SO_4 unites with the zinc and forms Zn_2SO_4. The H set free tends to collect upon the surface of the negative element, and in this way the copper finally becomes "polarised" by the hydrogen. The positive element, the zinc, always drives the positive electricity through the fluid toward the negative element, the copper. The wires which conduct the currents from one element to the other are called electrodes, and the one coming from the zinc is the negative electrode, and the one from the copper is the positive electrode. While zinc is universally used for one element, the second element in the battery may be composed of different kinds of metals, according to convenience.

A difficulty in using zinc as the positive element was soon found in the fact that little local currents were set up between it and the impurities contained in it, and this caused an unnecessary waste of the zinc. So it became customary to amalgamate the zinc in order to prevent this local action of the fluid

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upon it. The next improvement made was to prevent the little bubbles of hydrogen from collecting on the surface of the copper, thus keeping the liquid from coming in contact with it in all parts—that is, to prevent the "polarisation" of the copper. For this purpose certain substances came to be used to absorb the hydrogen. The first of these substances was the sulphate of copper as used in the Daniell battery. This consisted of a copper vessel containing a porous cylinder in which was suspended a rod of zinc. Dilute sulphuric acid was contained in this cylinder, and in the copper vessel outside of the cylinder was placed a solution of the sulphate of copper. In this battery the hydrogen set free decomposes the sulphate of copper, forming with it sulphuric acid, and sets free copper which collects on the copper element.

Grove's battery consists of a glass vessel containing a porous cup surrounded on the outside of a coil by amalgamated zinc, and on the inside is suspended a rod of platinum instead of copper. The vessel outside of the porous cup is filled with dilute sulphuric acid, and inside with strong nitric acid. The nitric acid absorbs the hydrogen set free by the sulphuric acid and zinc. In the bichromate battery the bichromate of potash dissolved in sulphuric acid is used to absorb the hydrogen, and chromic acid is formed. So the three substances in use for absorbing the hydrogen in different kinds of batteries are sulphate of copper, nitric acid, and bichromate of potash. Bunsen suggested the use of gas carbon to take the place of the copper, or the negative element, because of its cheapness. So the Bunsen battery consists of a cylinder of carbon immersed in a vessel containing nitric acid, and within this cylinder is a porous cell containing sulphuric acid, in which a rod of zinc is suspended. To avoid using the porous cups, the force of gravity has been brought into play in the construction of the so-called "gravity battery." This consists of a glass vessel with plates of copper at its bottom, and upon this crystals of sulphate of copper are scattered, while over all is poured pure water, in the upper portion of which is suspended a plate of zinc. A very little sulphuric acid is added to start the battery, and then its action will keep up. Gravity here keeps the two liquids apart—the solution of sulphate of copper at the bottom, and the dilute solution of sulphuric acid at the top. This battery produces a constant current, and will run for a very long time. The Leclanché battery consists of a porous cup containing sal ammoniac in which is suspended a rod of zinc, and this cup is surrounded by the oxide of manganese as a depolariser, immersed in which is the carbon. This battery is used when a current of electricity is desired for a very short time at once, as in striking burglar alarms, signal bells, &c. In the dipping battery a plate of zinc is suspended between two plates of carbon, and, when in use, these are let down into a solution of bichromate of potash dissolved in an excess of sulphuric acid. This fluid is called the electro-poion. The galvanic battery is now being replaced for many purposes by dynamo-electric machines.

The Electric Light.

If a strong current of electricity is sent along a good conductor, it passes very easily; but, if passed along a poor conductor, it makes it hot. This is the principle upon which is based the incandescent electric light. A current sent over a fine thread of carbon heats it to a white heat, and thus produces a brilliant light. The same principle holds in the arc light, where the air acts as the poor conductor. Here two pointed sticks of carbon are placed in contact until a current is started through them, and then they are gradually separated for a short distance, when the resistance offered by the air to the passage of the electricity from one point to the other heats them to incandescence, and small particles of carbon in a state of combustion are broken off and carried through the air, thus causing an arc of light between the carbon points. The incandescent electric light and the arc light form two systems of electric lighting.

A current of electricity passed through certain substances will decompose them, and this process is called electrolysis. If it is desired to plate any object with a metal, that metal should be hung upon the positive pole of a battery, and the object upon the negative pole, and then, when an electrical current is passed through them, the metal on the positive pole will be decomposed, and a layer of it will be deposited over the surface of the object hanging on the negative pole. This process is known as galvanoplasty.

The most convenient method of measuring a current of electricity is by means of a rotating needle, around which the current is passed; and this is called a galvanometer.

The Electric Telegraph.

The electric telegraph is based upon the production of temporary magnets by passing a current of electricity through a coil of wire surrounding a bar of soft iron. All systems of electro-telegraphing involve a battery, a wire, a piece of soft iron surrounded by a coil of wire, a key or current breaker, and a sounder or indicator. Morse devised an alphabet, the letters of which were made up by various combinations of dots and dashes, which were scratched upon a strip of paper by the indicator. But telegraph operators soon found that they did not need to see these letters on the paper, for the ear quickly became educated to detect the letters by sound alone; so the paper was discarded, and now they hear, instead of see, the dots and dashes.

The Telephone.

It is found that, if by any means you change the strength of the magnetism in a permanent magnet, you will at the same time change the strength of a current of electricity passing through a coil of wire surrounding the magnet, and it is upon this principle that all the modern telephones are constructed. If in front of such a magnet a thin sheet of iron is fastened, and if the plate of iron is then approached a little nearer to the end of the magnet, the magnetic centre is brought a little nearer to the extremity of the magnet, and hence the magnetic power at this point is increased; at the same time a similar increase is induced in the current of electricity passing through the coil of wire surrounding the extremity of this magnet; and now, if in the same circuit of wire there is a second similarly arranged apparatus, the increased strength of the current passing through the coil surrounding the second magnet will induce an increase in its magnetic power, and hence the second plate of iron will be attracted closer to the end of the magnet. In the same way a slight withdrawal of the first plate from the end of the first magnet would cause a weakening of the magnetism in the second, and cause its iron plate to spring backward again. So, in speaking in front of the first plate, at every vibration of the air produced by the voice the plate vibrates in harmony, and a precisely identical sort of vibration is produced in the plate of the apparatus at the other end of the wire, and these vibrations can be heard as the sound of a voice. This is all there is to the Bell telephone, and it is the principle on which all telephones are constructed.—*N. Y. Medical Journal.*

THE SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS.

At the meeting of this society on Thursday, 8th inst., Professor Adams in the chair, a paper communicated by Mr. Henry C. Mance, member, was read by Mr. Latimer Clark, who introduced it with some explanatory remarks of his own. Mr. Mance's paper described a method patented by him and practised on the Persian Gulf cables during the past four years, and by means of which he had been able to eliminate the effects of earth currents and polarisation when testing for a submarine cable fault. There existed in the recognised text books plenty of formulæ on this subject, but in practice they were of little service on board ship. His method was of great use wherever the loop test was not available, and it furnished a permanent and reliable test as a basis of calculation, doing away with all uncertainty as regards earth current and polarisation. Two observations were required rapidly succeeding each other, so that no change of condition could take place at the fault in the interval. An ordinary Wheatstone bridge was employed, with proportional coils which could be instantly changed by an

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apparatus of Mr. Mance's devising. Having two pairs of proportional coils of different values, say 100 and 1,000, the process was to make the test with one pair, and when steadiness was obtained to short-circuit the bridge for an instant, and then introduce the other pair. The formula for this method was as follows:—

Reading obtained with $\frac{100}{100}$ coils $= R^1$

Ditto with $\frac{1000}{1000}$ coils $= R^2$

Resistance of one of the proportional coils (100) $= P^1$

Ditto larger ,, ,, (1000) $= P^2$

Internal resistance of battery $= r$

Resistance of cable and of fault $= x$

Then
$$x = \frac{\overset{(A.)}{R^1(2r+P^2)} - \overset{(B.)}{R^2(2r+P^1)}}{R^2+P^2-P^1-R^1},$$

or
$$\frac{A-B}{\underset{(C.)}{C}} = x.$$

As an example of this working take the following:—

Battery (30 cells, negative) Resistance $= 4{\cdot}20$ ohms $= r$

$(P^1)\ \frac{100}{100}$ coils balance with 35 ohms $= r^1$

$(P^2)\ \frac{1000}{1000}$ coils ,, ,, 60 ohms $= r^2$

$$x = \frac{35 \times 1840 - 60 \times 940}{60 + 1000 - 100 - 25} = 8{\cdot}6 \text{ ohms.}$$

A large number of examples of how this method had served to correct the ordinary tests, and enabled Mr. Mance to localise cable faults with great certainty and celerity were furnished in the paper. Reverse currents not being used, and the tests following each other in quick succession, they are practically one. Mr. Latimer Clark added that Mr. Mance's method still left undetermined the resistance of the fault itself. As this resistance apparently increased with the distance between the fault and the observer, and with the strength of the battery, he suggested that it might be well to employ smaller proportional coils in these tests. He also drew attention to results obtained by himself so long ago as prior to 1862, and to tables published in *The Electrician* that year, the figures of which seemed to point to the possibility of formulating a law for determining the resistance of the fault itself. Mr. Mance's method had in practice no doubt been used before; but the merit of his present communication was the formula given above, which would be found very convenient for use in cable laying and cable repairing operations. Messrs. Latimer Clark, Muirhead, and Co., are the sole makers of Mr. Mance's testing apparatus.

A brief discussion ensued, followed by the usual vote of thanks.

LEGAL.

Wandsworth Board of Works v. United Telephone Company.

The plaintiffs claimed an injunction to restrain the defendants from retaining or placing telegraph or telephone wires across the streets in Putney, on the ground that they are dangerous to persons using the streets. The defendants disputed the plaintiffs' authority to interfere with their wires, denying that they were dangerous to persons using the streets. The plaintiffs' surveyor at Wandsworth gave evidence as to several accidents to persons from the overhead wires which had come to his knowledge, including one which occurred at Islington, when a man was caught and killed by a wire that was blown down in a storm. All the cases of which the witness was able to speak had arisen either by accident to the telephone or telegraph poles, or to trees falling on the wires when blown down by the wind, excepting two, in which the accidents were caused by the wire breaking without the supports being struck. The wires at Putney were raised about thirty feet above the streets, but in some open spaces the height was only about twenty feet. They were made of galvanised iron or phosphor bronze, and were generally attached to house chimneys. They were in some instances taken across the streets obliquely with long spans between the supports. When they were blown down they fell sometimes with great violence, the wire in one case catching and becoming firmly twisted round a lamp post. In answer to Mr. Justice Stephen, the witness expressed his belief that if the wires were taken across the streets at right angles and secured on both sides, so that at these points they would not be affected by accidents occurring elsewhere, the danger would be greatly decreased. The plaintiffs' surveyor for Streatham and Tooting, and other witnesses, gave similar evidence, and the learned judge said the main question seemed to be whether the suspension of great lengths of wire across the road was dangerous. There was some evidence of the wires breaking down by reason of the wind, and if so that was a real danger. Counsel for the defendants submitted that to entitle the plaintiffs to succeed there must be a substantial nuisance, and that in this case there was no real danger. They called the defendant company's engineer and other witnesses in support of that view. The engineer said the length of the wire at Putney was about three-quarters of a mile, and that the greatest span was 105 yards. The breaking strain of the galvanised iron wire was between 600lb. and 800lb.; that of the phosphor bronze between 250lb. and 280lb. The company had little short of 10,000 miles of wires erected throughout the metropolis. The wires and attachments at Putney were in proper condition, and there was not the slightest danger to the public in the streets. There would be nothing gained by making any alteration. He had never known of any fatal accident to any individual by the breaking of any of the company's wires, excepting the Islington case and one somewhere about Blackfriars Bridge.—The learned judge said the only question before him was that which related to Putney. He was not going to decide the whole question with reference to all the wires.

On Tuesday Mr. Justice Stephen delivered a written judgment in this important case. According to *The Times* his lordship said the facts of the case were these:—The United Telephone Company is a joint stock company, not incorporated by any private Act. They lately erected for a private person a telephone wire connecting two of his places of business in Putney, and supplied it at each end with proper telephonic apparatus. The wire and the instruments are the property of the company and are maintained by them, their use being regulated by a contract between them and their customer. The wire is attached at eleven different points to chimneys, and is carried at several places for considerable distances over highways in the district. At one place it passes over the High-street in Putney at a very obtuse angle and some 30 feet above the ground. At this point the span from point to point of its attachments is about 143 yards, the greater part of which is over the street. The plaintiffs are the Wandsworth Board of Works, and by the Metropolis Management Act of 1855 (18 and 19 Vict., chap. 120, sec. 96) all streets being highways are vested in them and are under their control. The action is for an injunction to restrain the defendants from retaining the wire, without the plaintiffs' consent, in the position in which it is now placed. They put their case upon three distinct grounds, viz.—In the first place, they contend that the defendants are a company subject to the conditions of the Telegraph Act (26 and 27 Vict., chap. 112, sec. 12), and are as such forbidden to place a telegraph wire over, along, or across a street or public road without the consent of the body having the control thereof. In the second place, the plaintiffs said that as owners of the soil they had an absolute right to prevent the defendants from suspending wires over their road, upon the principle that the air above the road was as much theirs as the road itself. Again, in the third place, they said that these overhead wires were a nuisance, and exposed the persons using the street to danger. The first of these arguments, his lordship said, turned upon the construction of the Telegraph Acts, and was put as follows:—The Telegraph Act of 32 and 33 Vict., chap. 73, sec. 12, is incorporated with that of 31 and 32 Vict., chap. 110, which itself is incorporated with that of 26 and 27 Vict., chap. 112. Thus the Telegraph Act of 1869, 31 and 32 Vict., chap. 110, is incorporated with that of 1863, 26 and 27 Vict., chap. 112. But in the Act of 1869 telegraph company is defined to mean "any corporation, company, or person for the time being engaged in transmitting, or, by any instrument, incorporated to transmit, telegrams within the United Kingdom;" and in the case of "The Attorney-General *v.* the Edison Telephone Company" it was held that a telephonic message is a telegram. Therefore a telephonic company must be a telegraphic company, and as such is within the Act of 1869 regulating such companies. This being so, it is also under the 1863 Act, and the 12th section thereof applies to it. To appreciate this argument it is necessary to look at the objects of the three Acts. That of 1863 is intended principally to abbreviate legislation respecting telegraph companies authorised by Parliament. That of 1868 gives the Postmaster-General all the powers of a telegraph company under the former Act, and enables him to purchase on certain terms, set out in the Act, the undertakings of the various telegraph companies. The Act of 1869 gives the Postmaster-General a monopoly of telegrams (which has been held to extend to telephonic messages also), &c.; and no doubt this Act would operate to restrain the defendants from sending telephonic messages unless licensed so to do by the Postmaster-General. But it does not put private companies for telegraphic purposes into the same position as telegraphic companies authorised by Parliament. On the contrary, the short result of all the Telegraph Acts read together is to make the Postmaster-General the only telegraph company in England, and to give him all the powers for the erection of telegraphs which were by the Act of 1863 intended to be conferred on private telegraph companies incorporated under private Acts. The defendants are simply a joint-stock company licensed by the Postmaster-General to carry on business, from which they would, but for such license, be restrained by the Act of 1869. But it is clear to me that they have none of the powers of a company under the Act of 1863, and that this, the first argument of the plaintiffs, fails. The second argument is that the effect of the Metropolis Management Act of 1854 is to give the plaintiffs the same right to prevent a wire being stretched across the roads at any height as a private person has to prevent such a wire being suspended over his field or garden. This depends upon the effect put upon the words of the Metropolis Management Act of 1854. The words are—"All streets being highways, the pavements, stones, and other materials thereof, &c., shall vest in and be under the management, &c., of the vestry or district board of the parish in which such roads are situate." The interpretation of words almost

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identical to these, his lordship, continued, has been considered in several reported cases, particularly in "Coverdall v. Charlton" (3 Q.B.D., 376, and on appeal in 4 Q.B.D., 104). This case is recognised and followed and explained in "Rolls *v.* St. George's, Southwark" (14 Ch. Div.). His lordship, having recited the words discussed in these cases, said that they were held to vest the streets in the local board of management in whose district the streets are. The effect of those decisions appeared to be that the words used in the Public Health Act (which in all important particulars are identical to those of the Metropolis Management Act) give not only the management and control of the streets to such authorities, but even the property in the streets, for all purposes of such management and control. Lord Justice Brett in the above case says (4 Q.B.D., 121)—"Street means more than the surface; it means the surface and so much of the depth as is or can be used not unfairly for the ordinary purposes of a street.". Again, Lord Bramwell upon the same point says in effect, his lordship pointed out, that the local authority owned not only the surface of a street, but the soil to such a depth or thickness as might be necessary in carrying out any alterations, improvements, &c., that could possibly be or become incidental to a street as a street. Lord Bramwell further contrasted this limited view with the wider view in which it might mean that a man acquires property *usque ad cœlum* and to the centre of the earth. His lordship then continued that it seemed clear to him that the present case must be decided on these principles. The case referred to does not decide the extent of a street upwards; it merely limits and defines its extent downwards. It does so, however, upon grounds which appear to me to apply equally in either direction. If it can be shown that the management and control of a street requires some control of the air immediately above it as well as over the ground immediately below it, it seems to follow that the vesting of the street itself in the district board must involve property in part of the air above the surface of the street as well as property in part of the soil beneath it. Now, it is self-evident that the air above a street may be dealt with in such a way as to affect the safety and comfort of the street; as, for instance, if electric wires were stretched across it so as to stop or interfere with the traffic, such a case might no doubt be dealt with as a nuisance. But could it not equally be treated as a trespass? So long as the wires are at a height which interferes actually with the traffic the question is unimportant. But when they are supended as in the present case it becomes most important. His lordship then discussed briefly the evidence on the facts of the case, and continued:—Upon the whole, though I cannot say that absolutely no danger arises from the position of the wires, I do not think, apart from the question of trespass, that it would form an indictable nuisance. If it had been erected with the consent of the district board, and had been indicted by one of the inhabitants as a nuisance at common law, I should not have hesitated to direct a jury that there was no evidence of such a nuisance as would justify a conviction. This being so, the whole question in the case appears to me to be whether or not the street vested in the district board to such an extent above the ground that the suspension of the wires over it entitles them to an injunction. I was at first of opinion that it did not, and that the case resembled that of "The Wandsworth District Board *v.* London and South-Western Railway Company." His lordship having reviewed and distinguished that case from the present one, continued:—It seems to me that Parliament intended to give the district board proprietary powers over the street both upwards and downwards, in order to give them the power of judging of the expediency on public grounds of permitting or prohibiting various acts from time to time affecting the streets, and which, though not perhaps actual nuisances, might yet be considered by the public undesirable innovations. His lordship, having added a few general remarks, concluded his careful and elaborate judgment in these words:—For these reasons I give judgment for the plaintiffs in the terms of their statement of claim, with costs. But as the case is one of such importance, and will no doubt be considered further, and as I think the wire causes no appreciable annoyance or danger to the highway, this injunction is not to be enforced until after the hearing of the appeal, if the defendants do appeal from this judgment.

The United Telephone Company v. the London and Globe Telephone and Maintenance Company.

This case, which was tried before Vice-Chancellor Bacon, was for an injunction to restrain the defendant company from infringing the plaintiffs' patent. The patent, which was described in the pleadings as Blake's patent, was granted on the 20th January, 1879, to William Robert Lake, who in January, 1880, assigned his rights to Francis Blake, from whom in May, 1882, it was purchased by the plaintiff company. The patent was for an improved telephonic transmitter, the principle of which consisted in a self-adjusting apparatus for holding the diaphragm of a telephone by means of springs, and for regulating and modifying the variations of pressure between the two electrodes of the circuit of a telephone. The plaintiffs charged that the defendant company had in their possession a large quantity of telephonic apparatus manufactured according to, or only colourably differing from, the inventions comprised in Blake's patent, and in particular that they had recently acquired a large number of Blake transmitters. They claimed an injunction against the defendants, their servants, agents, and workmen, against manufacturing, selling, supplying, letting on hire, or using any of the said telephones or telephonic apparatus which infringed, or were only colourably different from the plaintiffs' patent. They also asked for the delivery up to them of such apparatus, for an account of profits, and damages. The case for the defence was that in May, 1882, the Attorney-General had, on the application of the plaintiffs, granted his fiat allowing the plaintiffs to disclaim certain parts of the specification of a patent granted to Mr. Edison which had been decided by Mr. Justice Fry to be bad. The fiat was granted on condition that no proceedings for infringement should be taken by the plaintiffs against the defendant company and others for using any instruments of the class included in the disclaimer. In June, 1883, the Attorney-General made an award exempting the defendants from any proceedings in respect of the 800 instruments which were the subject of the present action. The mounting of the electrodes in these instruments was admitted to be in accordance with Blake's patent; but in no other respect was the patent infringed. The instruments were lying unused in the defendants' possession. The defendants also denied the validity of the patent. In November, 1883, they offered to remove from each of the 800 instruments every part which constituted an infringement of the patent.

Mr. Theodore Aston, Q.C., Mr. R. E. Webster, Q.C., and Mr. Moulton for the plaintiffs asked for an injunction in the terms above stated, and that the instruments might be destroyed or delivered up to them. They would have been perfectly satisfied if the defendants had undertaken to export the instruments.

Mr. Hemming, Q.C., and Mr. T. M. Goodeve urged, on the authority of "Minter *v.* Williams (4 "Adolphus and Ellis," 251) and of "Noble's Explosive Company *v.* Jones ("Law Rep.;" 8, App. Cases 5)," that mere possession did not constitute an infringement, and that manufacturing or selling or using had to be proved in order to give a cause of action. The proceedings before the Attorney-General and the fiat also precluded the plaintiffs from the remedy which they sought. It was the plaintiffs' duty to have brought the Blake patent before the Attorney-General, so that the questions might have been dealt with then.

Mr. Moulton, in reply, said that as the fiat of the Attorney-General had nothing to do with the Blake patent, and only dealt with Edison's patent, it had no application to the present case.

The Vice-Chancellor said that the defendants were in possession of certain instruments which they practically confessed, and which were proved beyond the possibility of a doubt to be an infringement of the plaintiffs' patent. That in itself gave the plaintiffs a right to the injunction which they asked. The cases cited by the defendants had no application to the present, and the decision in "Noble's Explosives Company *v.* Jones" was founded upon totally different grounds. There was no force in the contention that the Attorney-General's fiat disposed of the question. The Attorney-General, acting in his judicial capacity, dealt only with the Edison patent, and permitted the plaintiffs to lodge a disclaimer of the Edison patent. But he had no authority to make any order with respect to the Blake patent, which was not before him. It turned out that defendants had 800 instruments which were an infringement of the plaintiffs' patent, and they attempted to excuse that possession on the untenable ground of the Attorney-General's fiat. They also stated that they had no intention to use the instruments. If that were so the injunction would do them no harm. The admission that the mounting of the electrodes was in accordance with the specification in Lake's patent of January, 1879, and the offer to remove from the instruments all such parts as infringed the plaintiffs' patent rights was an admission of the whole of the plaintiffs' claim. The plaintiffs therefore were entitled to the fullest protection he could give them. He did not, however, see his way to ordering a delivery to the plaintiffs of the offending instruments, but he would grant an injunction.

Mr. Hemming urged that the offer of last November to dismantle the instruments and keep them dismantled would have given the plaintiffs all they asked. He therefore asked that the defendants might have their costs since that offer, or at all events that no costs should be given.

The Vice-Chancellor said that Mr. Hemming always died hard, but he could not forget that the plaintiffs offered to allow the defendants to export the instruments. The defendants must pay the costs of the action, and the injunction must go in the terms asked.

Muir and Company v. The Anglo-American Brush Company.

In this case Mr. Ambrose, Q.C., Mr. Bigham, Q.C., and Mr. J. A. Hamilton, appeared for the plaintiffs; Mr. Gully, Q.C., and Mr. Collins, Q.C., for the defendants. Messrs. Muir and Co., engineers and toolmakers, Manchester, are the plaintiffs; the defendants are a limited company. The defendants ordered from Messrs. Muir a facing and boring machine, intended to be used in the production of dynamo machines. When the machinery was completed, and an intimation had been given that it was ready for delivery, the defendants refused to accept it on the ground that the machine had not been supplied within the time that it ought to have been, according to the understanding which was entered into when the order was given. The plaintiffs maintained that no specific time was ever fixed during which the contract was to be completed, and that the machine in question (in the manufacture of which a large amount of skill and care were needed) was completed in as short a time as was possible for the work to be done satisfactorily. The matter at issue has been thrice before a jury. On the first occasion the jury returned a verdict for the plaintiffs. A new trial was afterwards obtained by the defendants. On that occasion the jury were unable to agree, but Mr. Justice Butt, who heard the case, entered a verdict for the defendants on a point of law. The plaintiffs afterwards carried the matter to the Court of Appeal, the result being that the Master of the Rolls (Lord Justice Brett) ordered another trial on the ground that there was no question of law on which a verdict for the defendants ought to be given, the only question to be determined being whether the machinery was completed and delivery tendered within a reasonable period after the order was given. After numerous witnesses had been examined the jury consulted together for a considerable time in private, and returned a verdict for the full amount agreed upon, £736.—Mr. Gully applied that execution might be stayed in order that the matter might be taken before a superior court.—Mr. Ambrose opposed the application, and stated that

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that was the second time a jury had found in favour of the plaintiffs. He thought under these circumstances it was not advisable that execution should be stayed.—Mr. Justice Day said he saw no reason, looking at the previous history of the case, why he should not consent to stay execution. There could be no very great hurry in the matter; execution would therefore be stayed.

Submarine Cables Trust.

The thirteenth ordinary annual meeting of the certificate holders in this Trust was held at the offices, 66, Old Broad-street, on the 13th inst., under the presidency of the Most Hon. the Marquis of Tweeddale.

The SECRETARY (Mr. Lewis Wells) read the notice convening the meeting and the minutes of the last meeting, and the report of the directors was taken as read.

The CHAIRMAN: Before offering a very few remarks on this occasion I think it right to say that Mr. Pender, one of our trustees, and occupying the chair on these occasions, is absent at this moment, as he is with a deputation to the Postmaster-General with respect to certain matters connected with telegraph business. The accounts which have been submitted to you show that the revenue of the past year amounted to £23,991, against £22,064 in the previous year, being an increase of £1,927. That is due to the dividends on our investment in the Anglo-American and the Eastern Extension stocks being increased. In the one case the difference is as between 3¼ per cent. and 2¾ per cent., and in the case of the Eastern Extension Company the increase is ½ per cent. You are aware that a competition is threatened in respect to the Atlantic cables, and no doubt that competition will influence the receipts of these companies directly, and therefore, indirectly, the receipts of this Trust. It is not for me to express any opinion as to how far that will be the case, but it is satisfactory to us to be able to look forward to increased receipts from other quarters—from the Eastern, Eastern Extension, and other companies in which we are interested, which will enable us, with the considerable sum of £3,943, which we now carry over, to meet our engagements in the future. I do not think there is anything more to be said with respect to the report, but if any gentleman would like to ask any question on any doubtful point I should be happy to answer him. I now beg to move "That the report and accounts now submitted to the certificate holders be received and adopted."

Mr. PENDER, M.P. (who had entered the room in the course of the chairman's remarks), seconded the resolution, which was carried unanimously.

On the motion of Mr. LAMONT, seconded by Mr. LUCAR, Messrs. John G. Griffiths and John Gane were re-elected auditors for the current year.

A SHAREHOLDER inquired whether, in view of the Trust being so small and compact, the certificates could not be registered in case of robbery or fire.

The CHAIRMAN: This question has already been before us, and difficulty arises from the fact that we do not know who the certificate holders are. You mean that the holders who wish to have them registered should have the means of doing so?

The SHAREHOLDER assented.

The CHAIRMAN: We will again consider the matter, and if it is feasible and can be done at no great cost, it may possibly be done, if it is the general wish.

The SECRETARY stated that it would involve a good deal of expense, and the question was, was it worth while incurring that expense?

On the motion of Mr. LAMONT a vote of thanks was passed to the chairman and directors, and

The CHAIRMAN having acknowledged the compliment, the proceedings terminated.

TRAFFIC RECEIPTS FOR APRIL, 1884.

COMPANIES.	April, 1884.	April, 1883.	Increase.	Decrease.
Cuba Submarine	3,300	3,982	—	682
Direct Spanish Telegraph	1,800	1,778	22	—
Direct United States	—	—	—	—
Eastern Extension	31,246	32,005	—	759
Eastern Telegraph	51,974	45,148	6,826	—
Great Northern	21,040	—	—	—
Submarine	—	—	—	—
West Coast of America	3,465	—	—	—
Western and Brazilian	—	—	—	—

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. MAY 14.		BUSINESS DONE WEEK ENDING MAY 14. Highest.	Lowest.
Anglo-American	81½,	82½	33⅛	31
Do. Preferred	67½,	58½	59⅛	57½
Do. Deferred	6,	7	7⅝	6
Brazilian Submarine	10⅛,	10⅝	10⅝	10⅛
Cuba	9¾,	10¼	10	9 15-16
Do. Preference	16½,	17½	17	16⅝
Direct Spanish	4½,	5	4¾	4¼
Do. Preference	14,	14½	14¼	13¾
Direct United States Cable	9⅝,	9⅞	9 15-16	9 13-16
Eastern Telegraph	10⅞,	11⅛	11 1-16	10⅞
Do. 6 per Cent. Preference	13,	13½	13 7-16	13⅜
Do. 5 per Cent. Debentures, 1899	102,	106	—	—
Eastern Extension	11½,	11¾	11 11-16	11½
German Union	9¾,	10¼	—	—
Globe Telegraph and Trust	6⅜,	6⅝	6⅝	6 7-16
Do. Preference	12⅜,	12⅝	12 9-16	12⅜
Great Northern	13⅜,	13⅝	13⅝	13⅜
Indo-European	31,	32	31¾	—
Mediterranean Extension	1¼,	1¾	1¼	—
Do. Preference	2,	4	—	—
Reuter's	8,	8½	8⅜	—
Submarine	150,	160	159	153
West India and Panama	⅞,	1⅛	⅞	—
Do. 1st Preference	7,	7½	7⅛	7 1-16
Western Brazilian	5⅜,	5⅝	5½	5 7-16
Western Union 7 per Cent 1st Mortgage	121,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	106	—	—

TELEPHONES.

COMPANIES.	CLOSING PRICES. MAY 14.		Highest.	Lowest.
Consolid. Telephone and Maintenance	3-16,	5-16	—	—
Oriental	⅛,	⅜	—	—
United Telephone	7½,	8	8½	7¾

ELECTRIC LIGHT.

COMPANIES.	CLOSING PRICES. MAY 14.		Highest.	Lowest.
Anglo-American Brush Light (£7 paid)	1½,	1¾	1 13-16	1½
Do. (fully paid)	3½,	4	—	—
Hammond Light (£3 15s. paid)	⅜,	⅝	¾	½
Eastern Electric (£4 paid)	—	—	—	—
Swan	¾,	1	15-16	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

COMPANIES.	CLOSING PRICES. MAY 14.		Highest.	Lowest.
Telegraph Construction	33,	34	33¾	33½
India Rubber, Gutta Percha, and Telegraph Works	23½,	24½	24½	23¾

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NOTES.

THE SOUDAN.—Telegraphic communication is now restored as far as Debbeh.

ELECTRIC LIGHTING IN PARIS.—The Cercle des Arts Libéraux is lighted by the Edison system.

CENTRAL NEWS v. EASTERN TELEGRAPH COMPANY.—A new trial will be moved for in this case.

THE TELEPHONE IN GERMANY.—Merchants in Mannheim are crying out against the high rates for telephone subscriptions.

ORIENTAL TELEPHONE COMPANY.—Colonel G. E. Gouraud has been elected chairman of the board of directors of this company.

ELECTRIC LIGHTING IN WASHINGTON.—The Edison Company are to light the Government printing office at Washington, U.S.A.

INDIA RUBBER, GUTTA PERCHA, &c., COMPANY.—This company's Bill was read a second time in the House of Commons on Wednesday.

ERRATUM.—In Mr. Kapp's article on "Dynamometers," published in our last issue, Mr. Smith's initials should be "F. J.," and not as therein printed.

UNDERGROUND WIRES IN CHICAGO.—A conduit is to be laid through Chicago to accommodate about sixty wires for the Bankers' and Merchants' Telegraph Company.

DEATH OF MR. TRABUE.—The death is announced of Mr. George W. Trabue, general superintendent of the Southern Division of the Western Union Telegraph Company.

CYCLONE IN BRITISH BURMAH.—On Monday a cyclone passed over Akyab, causing considerable damage to property and shipping, and interrupting telegraphic communication.

WAS THERE A LIGHTNING CONDUCTOR?—During a severe thunderstorm in Calcutta recently a jute warehouse was struck by lightning, and property to the extent of 70,000r. destroyed.

ELECTRIC LIGHT ON STEAMERS.—The Canadian Pacific Railway Steamers "Arthabasca," "Algoma," and "Alberta" will be lighted by the Canadian Edison Electric Light Company of Hamilton.

THUNDERSTORM.—During a severe thunderstorm which occurred at Pontardawe, South Wales, recently, the church and an adjoining house were considerably damaged, the windows being nearly all smashed.

TELEGRAPHIC RECEIPTS IN FRANCE.—The receipts from the telegraphs in France for the first quarter of this year amounted to 8,397,100 francs, or about 663,400 francs less than the estimated receipts.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended May 15 are £2,959, as compared with £3,368 in the corresponding period of 1883.

THE LALANDE-CHAPERON BATTERY.—This battery is now to be seen at work at the offices of Mr. Hugh A. Fergusson, 31, Lombard-street, E.C. We shall shortly give a detailed description of it with illustrations.

APPOINTMENT.—We understand that Mr. Henry C. Graham, late superintendent in Devon and Cornwall to the United Telephone Company, has been appointed manager of the Electric Apparatus Company, of Charing-cross.

TELEGRAPH TARIFFS.—On Wednesday evening Lieut.-Col. Webber, C.E., read a paper on this subject before the Society of Arts. He supported the introduction of a sixpenny tariff. We shall hope to print the paper in our next issue.

LIVERPOOL ELECTRIC SUPPLY COMPANY.—The directors of this company have, out of the profits of the past year, paid a dividend at the rate of 5 per cent. per annum, and have carried forward a similar amount to the current year's account.

ELECTRIC LIGHTING IN ST. LOUIS.—The Custom House and Post Office at St. Louis, U.S., are to be lighted by the United States Electric Lighting Company. The plant will consist of 30 Weston arc lamps and 750 Maxim incandescents.

PROVISIONAL ORDERS.—The Electric Lighting Provisional Order Bill (No. 3) was read a second time in the House of Commons on Monday. The Electric Lighting Provisional Order (No. 2) Bill was read a second time in the House of Lords on Tuesday.

NOTICE OF REMOVAL.—Messrs. Newton and Son, patent agents and mechanical draughtsmen, have removed from their old premises, at No. 66, Chancery-lane, where they have been for nearly seventy years, to new offices at 6, Bream's-buildings, Chancery-lane, W.C.

A TELEGRAPH CLERK TAKEN PRISONER.—*The Times* correspondent at Alexandria telegraphed on the 19th inst. that Signor Cuzzi, a telegraph clerk lately stationed at Berber, and an Italian subject, had been captured by the rebels at Eshrara, some fifty miles from Berber.

ELECTRIC LIGHTING IN JAVA.—A correspondent in Java writes that the palace of Prince Manko-Negoro at Soerakarta is lighted by 46 Swan lamps and five Siemens arc lamps. The current is conducted from the machine room by an underground cable about one mile long.

THE POST OFFICE AND THE TELEPHONE.—In the House of Commons on Monday, Mr. Gray gave notice that he would on the vote on account call attention to the postal arrangements between England and Ireland, and to the attitude of the postal department with respect to telephonic communication.

TO BE WOUND UP.—A petition for winding up the South Kensington Mutual Electric Lighting and Supply Company was presented to the High Court of Justice on the 19th inst. by Messrs. Burchell and Co., of the Sanctuary, Westminster, S.W., and will be heard before Mr. Justice Kay on the 30th inst.

THE HOCHHAUSEN DYNAMO.—We are informed that Mr. H. Edmunds, of 2, Victoria-mansions, S.W., has made arrangements at his factory in Halifax for the manufacture of the Hochhausen dynamos, &c., under the superintendence of Mr. P. J. Charles, late foreman of Messrs. Emmerson and Murgatroyd's works.

TELEPHONE WIRES IN PHILADELPHIA.—The latest from Philadelphia states that the manager of an insurance company gave orders for thirty telephone wires which were fixed to the roof of the company's office to be cut and thrown into the street. The orders were carried out. It remains to be seen what the telephone companies will say.

THE TELEPHONE IN THE SCILLY ISLANDS.—The house of Mr. Smith-Dorrien, "Lord" of the Scilly Isles, situated on the Island of Tresco, is connected by telephone with the house of his steward, which is on St. Mary's, another

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island. The distance between the two islands is about three miles, and the line is laid under the sea.

THE TELEPHONE IN AMERICA.—The New England Telephone Company has instruments in 472 towns in the New England States, and has 109 exchanges at work. In Boston it has 2,386 subscribers, Lowell 959, Lynn 501, Manchester 403, Portland 727, Salem 320, Springfield 588, Worcester 784. The total number of subscribers to the company's system is 17,820.

EARTHQUAKES IN TURKEY.—During the last fortnight there have been several shocks of earthquake on the Asiatic shore of the Sea of Marmora. On Monday an unusually severe one did a great amount of damage to the villages on the peninsula of Cyzicus. A correspondent of a daily paper states that many houses were destroyed, though the loss of life is nowhere estimated at beyond twenty.

CROMPTON V. MAXIM-WESTON COMPANY.—In all probability for the first time in the history of litigation a dynamo machine was to be seen in No. 8 Court, Queen's Bench Division, on Thursday last, when this case was put down for hearing. Fortunately the litigants agreed to settle their differences out of court. We wish that all litigation connected with electrical matters could be as readily settled.

NEW PAPER.—We have received a copy of No. 3, Vol. I., of the *Canadian Electrical News*, which is apparently the last venture in electrical journalism. Although of modest dimensions at present, viz., eight pages, we have no doubt it will soon grow, as the electric light, telephone, and telegraph are making rapid strides in the Dominion. The *News* is published at Montreal and edited by Mr. John Horn.

DEATH OF M. CHARLES BONTEMPS.—The death is announced at the age of 45 of M. Charles Bontemps, of the French telegraph service, which he entered in 1860. He attained the rank of inspecting-engineer, and had special charge of the pneumatic and underground service. He was one of the founders of the French journal *L'Electricien* and a frequent contributor to its columns. He died suddenly on the 6th inst.

TRANSMISSION OF POWER.—Experiments on the transmission of power by means of electricity have lately been carried out at Biel, in Switzerland, by Messrs. Meuron and Cuenod, of Geneva. Water power was used to drive the transmitting dynamo, and the circuit was composed of a copper wire 7mm. diameter and 1,200 meters long. Thury machines were used, and the speed is said not to have exceeded 400 or 500 revolutions per minute.

THUNDERSTORM IN IRELAND.—A fearful thunderstorm passed over Warrenpoint and neighbourhood early on Wednesday morning. The Killowen Roman Catholic chapel, where the celebrated Yelverton marriage was performed, was struck by lightning, and the greater portion of it destroyed. The telegraph wires between Rostrevor and Kilteel were broken, and a large number of sheep which were grazing upon the mountains were killed by the lightning.

FAST SPEED TELEGRAPHY.—Speaking of the recent contest amongst Morse operators in London, the *New York Operator* says:—"We are willing to admit that England can produce as fast operators as we can, but we claim that with their lumbering code of signals as against our rattling combination we can beat them, everything else being equal. We have sworn records of fast Morse sending at the rate of forty two words a minute for sixty consecutive minutes—over 2,500 words in one hour."

THE FURNITURE EXHIBITION.—At this exhibition, which was held in the Agricultural Hall last week, the Anglo-American Brush Company had a D_2 Victoria machine at work, supplying current to 100 of their Victoria lamps in different parts of the hall. Among the stalls illuminated we may mention those of Messrs. Druce, Messrs. Procter, and others. The whole of this installation was successfully worked and carried out by Messrs. Gretton, Thynne, and Co., electrical engineers and contractors.

ELECTRIC LIGHTING FOR MINES.—In 1861 proposals were made to provide an electric light for safety lamps by means of an electro-magnetic apparatus. The first form of electric safety lamp was constructed by Benoit and Dumas. It consisted of a zinc-carbon battery, a Ruhmkorff induction apparatus, and a Geissler tube. This lamp was for a time used in the Saarbrücken mines, but it was too heavy and too fragile, and as, moreover, its illuminating power was comparatively low, its use has been very much limited.—Herr Hoernecke, of Halle, in the *Verhandlungen des Vereins für Beförderung des Gewerbfleisses.*

ELECTRIC LIGHT IN FLOUR MILLS.—Messrs. W. and J. Bairstow, of Keighley, whose mills have been lately reconstructed, have adopted the electric light. The installation consists of one Crompton-Burgin dynamo machine of the self-regulating type, which feeds sixty-two 20 candle-power Swan lamps, 110 volts, which light the mill, boiler and engine houses, and offices. As usual the machine is placed on the ground floor, and is driven from a countershaft at a speed of about 1,450 revolutions per minute. This is the first time the light has been tried in Keighley. The work has been done by Mr. Wilson Hartnell, of Leeds.

FAURE-SELLON-VOLCKMAR ACCUMULATORS.—The Electrical Power Storage Company announce that a reduction has been made in the prices of these accumulators, and that some new types are ready for supply. The ordinary accumulator cell, with either glass or wooden boxes, contains 15 plates per E.H.P., the normal rate of charge being 20 amperes, and of discharge 30 amperes. A stronger pattern, with 13 plates, is also made, having a discharge rate of 26 amperes. Special cells are constructed, with plates of extra strength, for use as regulators for installations on the incandescent system. The company state that the useful E.M.F. of each cell may be taken as 2 volts, although for a short time after charging it is as high as 2·15 volts.

A SIMPLE ELECTRO-DYNAMOMETER.—Signor Bellati substitutes for the needle of a reflecting galvanometer a small cylinder of soft iron, bifilarly suspended in a direction perpendicular to the magnetic meridian, and inclines the vertical coil through which the currents to be measured pass to 45° from this meridian. In point of fact the earth's action is nullified, since the soft iron remains practically perpendicular to the magnetic meridian, and as its magnetism changes its character with the direction of the current the electro-magnetic action always maintains the same sign, like the electro-dynamic action in the electro-dynamometer. A closely-packed bundle of soft iron wires, of ·15m. diameter and 17m. long, may be substituted for a soft iron cylinder.

STRANDING OF THE "RETRIEVER."—A telegram received at Lloyd's from Syra states:—"The Eastern Telegraph Company's steamer 'Retriever' stranded on Saturday morning at North End, Santorin, and her forehold as far as the main tank is full of water, and it is feared bottom badly damaged. Discharging cable ashore to lighten the ship. Wired Syra for

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assistance. All that is possible will be done to save the ship if the weather keeps fine." A further telegram from Syra states:—"'Retriever' grounded on reef, Cape Mavropetra, Santorin, at 10 a.m. Saturday morning. Fore part full of water. Now discharging cable and using every endeavour to get the ship off." The "Retriever" is an iron screw steamer of 457 tons gross, built at Glasgow in 1879.

TELEGRAPH MATERIALS WANTED.—The Great Eastern Railway Company is inviting tenders for the supply of telegraph materials and india rubber. Forms of tender can be had at the Secretary's Office, Liverpool-street Terminus, E.C., and patterns can be seen at the stores at Stratford, between 10 a.m. and 4 p.m., up to the 29th inst. Tenders to be sent in to Mr. J. Hadfield, secretary, Liverpool-street Terminus, by 10 a.m. on the 31st instant. The North-Eastern Railway Company also require tenders for the supply of telegraph stores during the six months ending December 31. Forms of tender may be obtained on application to Mr. Graves, Telegraph Department, York, and tenders must be sent to the secretary at York, sealed and marked "Tender for Telegraph Stores," by noon on the 29th inst.

ELECTRIC LIGHT IN COLLIERIES.—A most satisfactory and successful electric light installation has just been completed at the Park Pit Ocean Collieries, South Wales. The motive power is supplied by a 6 horse-power Marshall engine, fitted with Hartnell's patent automatic expansion gear, driving a Crompton-Bürgin self-regulating dynamo. There are fifty 20 candle-power Swan incandescent lamps distributed underground and on the surface over the screens, workshops, and engine houses. The novel feature in the installation is the very successful manner in which the bottom of the pit is lighted, and 150 yards of the workings, as far as the main engine roads. The work has been carried out by Mr. J. C. Howell, Llanelly, agent for Messrs. R. E. Crompton and Co., assisted by the officials of the colliery.

THE FRENCH ACADEMY OF SCIENCES.—At the annual meeting of this Academy, held a few days since, the Fourneyron Prize was presented to M. Marcel Deprez, for his experiments on the transmission of power by means of electricity. The Lacaze Prize was awarded to M. Henri Becquerel for his labours in experimental physics. M. Gaston Tissandier received a portion of the Penaud Prize for his experiments on the steering, &c., of balloons by electrical means. It was resolved that the subject of the grand mathematical prize for 1884 should be "The perfecting of the theory of applying electricity to the transmission of energy." This prize consists of a medal valued at 3,000 francs (£120). The subject of the Bordin Prize for 1885 will be "The origin of atmospheric electricity, and the causes of electrical phenomena during storms."

RESISTANCE OF ARC LAMPS.—The ordinary voltaic arc of the lighthouse, according to M. F. Lucas, plays between the points of two Carré carbons of 16mm. diameter, the distance between which is maintained very nearly constant (on the average 4mm.) by the action of a Serrin regulator. In a recent note to the French Academy of Sciences, M. Lucas states that by causing the current sent through the arc to vary between 40 and 75 amperes, and the distance between the points of the carbons from 0 to 9 millimetres, he found the resistance of the arc ζ could be represented by the formula $\zeta = \cdot 40 \text{ ohm} \left(1 - \frac{1}{80 \text{ amp.}}\right)\left(1 + \frac{\epsilon}{1\text{mm.} \cdot 4}\right)$. With a current of 50 amperes and a distance between Carré carbon points of ·004m., the normal state of affairs in the French lighthouse service, the resistance of the arc is found to be ·58 ohm.

ELECTRIC LIGHTING IN THE CANARY ISLANDS.—We learn that it is proposed to light the city of Las Palmas, the capital of the Island of Gran Canaria—and not, as we inadvertently stated in a previous number, of the Archipelago—by means of the electric light. The Spanish Government Engineer of Woods and Forests, Don Clemente Figuera, holds the concession from the Corporation for carrying this proposal into effect, and the machinery and material are now arriving in instalments from France. The first portion of the installation will consist of about one hundred arc lamps, which will illuminate several of the principal streets and squares of the city, and from the success of this it will be decided whether to adopt the electric light as a permanency, and extend its use to other parts of the city, or otherwise. The only artificial illuminating agent at present in use in the streets of Las Palmas is oil, and for a part of each month this is dispensed with in favour of the moon.

INTER-COLONIAL TELEGRAMS.—A request was recently presented to the Postmaster-General of Victoria by a deputation from towns contiguous to the South Australian border, that instead of an inter-colonial charge of 2s. being made for telegrams interchanged between border towns on either side which were only a few miles distant from each other, messages should be transmitted at the same rate as if they had not to be delivered outside the colony—namely, 1s. for ten words. The postal department has since been in correspondence with the South Australian Government on the subject—says the *Colonies and India*—and the Postmaster-General of the latter colony has replied to the effect that it would be difficult to draw a line defining the distance from the border or the particular towns to which the proposed concessions should be extended. In a subsequent communication he states that after giving careful consideration to the matter the Government did not consider the proposed arrangement desirable, and were unable to approve of it.

THE ELECTRIC LIGHTING ACT.—At the last meeting of the St. James's (Westminster) Vestry, the Lighting Committee presented a report recommending, with reference to the St. James's, Westminster, St. Martin-in-the-Fields, and St. George, Hanover-square, electric lighting order, as settled by the Board of Trade, that the Vestry do convey to the Board of Trade an expression of regret that the Board has not seen fit to adopt the Vestry's views with regard to amending Schedule C (sec. 1), by providing that the undertakers may make a minimum charge for 250 units of electricity per annum (equivalent to £7 5s. 10d. per annum), in lieu of a minimum charge of £3s 10s. per quarter, and that the Board be informed the Vestry still entertain a very strong opinion that the power of the undertakers to make a minimum payment of £3 10s. per quarter a condition of supplying electricity will operate with special hardship on small consumers. The committee reported that, with the foregoing exception, they see nothing in the said order appearing to call for special remark.—This was adopted.

UNIVERSITY COLLEGE, NOTTINGHAM. — The chair of engineering in this college is vacant, and applications are invited for the professorship. The professor of engineering will have the management of the college workshops, and must have a practical acquaintance with the ordinary operations of the foundry and fitting shop. He should also have a technical knowledge of electrical engineering. In addition to supervising the practical work of students, he will be expected to

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conduct classes in mechanical, civil, and electrical engineering, and must be prepared to devote several evenings a week during the winter months to the conduct of classes for artisans. His remuneration will consist of a fixed stipend of £200 per annum, together with half the fees of the workshops and classes in his department, and any Government or other grants earned by his students in examinations. Applications, with testimonials and references, should be sent before June 10, to Mr. S. G. Johnson, town clerk, Municipal Offices, Nottingham, from whom further particulars may be obtained.

Overhead Wires in New York.—The *Scientific American* thinks that if the telegraph and telephone companies in New York are compelled to put their wires underground they will raise their rates in order to cover the extra expense entailed upon them. Our contemporary is of opinion that a plan might be devised by which the wires could be systematically led over the roofs of the houses, without proving a special hardship or annoyance to any one, and thinks it somewhat surprising that no such plan has been considered. It continues:—"There is good reason to believe that, with proper supervision by constituted authorities, the general and indiscriminate scrambling over roofs now indulged in by line men could be avoided in great measure. The unsightly street poles could be done away with, and the wires now strung on them be laid in the same order over roofs of the houses. When damage of any kind resulted, such as injury to a chimney or roof, those who had general supervision over all the wires could readily decide who was responsible for it, and hence who must repair the injury done."

A Curious Experiment.—It is known that if there be a primary circuit comprising a microphone, a Leclanché battery of, say, three cells and the primary wire of an induction coil, and a secondary circuit comprising the secondary wire of such coil, another Leclanché battery of, say, 12 cells, and two metal contact pieces, such as are used for medical purposes, and if two persons each hold a contact piece in one hand, and one of them lays his disengaged and gloved hand on the ear of the other, the latter will hear words that are spoken into the microphone, as if they came out of the other's hand. At a recent meeting of the French Physical Society, M. Hospitalier modified the above experiment by replacing the gloved hand by a piece of ordinary paper. Two persons took hold of the contact pieces as before, and placed their heads together ear to ear, with the paper between, and could hear all that was said at the microphone. Further, holding the contact pieces as before, these two laid their disengaged hands on the ears of a third person, who again heard what was spoken into the microphone, the hands appearing to talk.

International Forestry Exhibition.—The Anglo-American Brush Electric Light Corporation have received the order for lighting the buildings and adjacent grounds of the International Forestry Exhibition, to be held in Edinburgh during the present year. The apparatus which is to be supplied for the purpose will consist of four No. 7 Brush "arc" machines, forty-six of the Corporation Brush-Sellon lamps for indoor use, and fifteen Brush arc lamps, fitted in hexagonal lanterns, for use in lighting the exterior portions of the building and adjacent grounds. The Brush-Sellon lamps are, from their steadiness, admirably suited for indoor illumination. Besides the above apparatus, various parts of the building will be lit by the incandescent light. For this the Corporation are supplying two of their E_2 compound Victoria machines, each capable of maintaining 250 20 candle-power 60 volt lamps. These 500 lamps, the type of which will be the Corporation's Victoria lamp, will be employed for lighting the corridor leading from the main entrance, the refreshment rooms, and other parts of the building where arc lights would be unsuitable.

Electric Lighting in Chicago.—The City Council of Chicago not long since passed an ordinance laying down certain regulations for the running of electric light wires so as to insure some uniformity and to provide against ignorant and careless work. To show how necessary this ordinance was it is only requisite to quote from a report prepared by an inspector sent round by the council to see into this matter. During his visits the inspector reports finding wires insulated with paraffin coverings, sometimes only singly wound, sometimes with a braided envelope; wires of less conductivity by several sizes than that considered safe, smaller by several numbers than that used by any arc light company of the present day; wires with no insulation whatever, nailed to wooden partitions, with iron staples, these latter reaching to and in contact with wire lathing, thus forming a partial ground connection. In several instances wires of as many as two or three sizes were found upon the same circuit. In addition to all this, instances were found where wires were not only naked, or imperfectly insulated, but so near together as almost to touch, and both within close proximity to iron columns, water and gas pipes, and the like.

Electric Gas Lighters.—The stables of Mr. Cornelius Vanderbilt, of New York, are lighted throughout with gas; but as matches are not allowed each burner is provided with an electrical arrangement for lighting it. The current is generated by four "Diamond" carbon batteries, one pole being connected to earth by contact with the nearest gas-pipe, and the other being led in the first place into a primary induction coil. From the coil the wire passes to a clock-mechanism and switchboard, whence the different circuits start. At the burner the wire is connected to a metal ring, which encircles the lava tip, and has a projecting point opposite the slit. On the body of the burner-connection is a spring crank, which bears on one lever a wiping contact piece, and on the other a hanging button. When the button is pulled, with the gas turned on, the electrical circuit is closed by the contact of the wiping spring with the point of the ring on the burner; and on being released, a spark is drawn out, which lights the gas, while the crank falls back out of the way. The lighting current must thus be connected at two points—the switchboard and the burner—before a gas-jet can be lighted. The object of the clock-mechanism is to break the circuit if by accident it should be left connected to earth for more than ten seconds.

Counting Papers.—Mr. George Rosquist, the machinist of the New York *Sun*, is the inventor of an electrical apparatus by which papers are counted and registered as they leave the steam presses. It is simple and complete, and has been in successful use on the *Sun* presses for several months. Unlike the other paper-counting apparatus now in use, which registers the revolutions of the cylinders whether the paper is running over them or not, Mr. Rosquist's apparatus only registers the actual number of impressions made. On the male cutting cylinder of the press is fastened a bowed strip of brass about three inches long and one inch broad. On it is a button which connects with a bell crank, which works a small rod connecting with a circuit switch in a box on one of the cylinder's journals. The switch connects, by wires from a small battery, with an electro-magnetic apparatus constructed on the prin-

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ciple of the Morse telegraphic instrument. The pressing of the button works the switch, which flies back to its original position when the pressure is removed. This works the bar on the electro-magnetic apparatus, which connects with the register by a lever. The lever moves a geared wheel, which registers either two or four papers, depending on the size of the press. The registers for the double presses register as high as 999,000, and those for the single presses register 99,000. In order to prevent the registering of revolutions of the cylinders when papers are not printed there is a small canal cut into the female cutting cylinder, into which the bowed strip of brass with its button sinks when the canal is not covered by the paper on which the impressions are made. The registers can be placed at any distance from the presses. Those used by the *Sun* are in the office of the superintendent of the paper department, on the floor above the presses.—*Electrical World*, New York.

Change in the Peltier Effect due to Variation of Temperature.—In the recently-issued *Proceedings* of the Royal Society of Edinburgh is a short paper by Mr. A. Campbell upon this subject. Mr. Campbell says:—"The object of this short paper is to give the results of some further experiments made with a view to determine the variation in the Peltier effect due to change of temperature. These experiments are the continuation of a set of similar experiments described in a paper read to the society in summer 1882. The arrangement used was almost exactly the same as that employed in the former experiments, the measurements being made by means of an iron German-silver thermopile bent into the shape of an arch, with the ends about ¼in. apart, and placed so as to almost touch the junctions of the metals whose Peltier effect was to be measured. The neutral points of the various pairs of metals were also measured in the usual way by heating up a junction in oil, plotting the temperature-deflection curve, and from it deducing the neutral-point. According to theory, the ratio of the Peltier effect at temperature t_1 to that at t_2 is determined *solely* by the values of t_1, t_2, and the neutral-point of the metal used; therefore it was not necessary to draw the thermo-electric lines of the metals. As I have no satisfactory measurement of the neutral point of Pb – Arg, in this case the calculated ratio in column V. is from Professor Tait's diagram. In the subjoined table, column I. gives the name of the pair of metals; II. and III. the lower and upper temperatures at which the Peltier effect was observed; IV. the ratio of the Peltier effects at these two temperatures *from the direct measurement;* V. the ratio calculated from the observed neutral-point given in VI.:—

I.	II.	III.	IV.	V.	VI.
Fe-Zn	23°·8 C.	99° C.	1·43	1·404	198° C.
Fe-Zn	28°·25	94°	1·373	1·3397	198°
Fe-Zn	24°·5	94°	1·429	1·353	198°
Pb-Zn	17°	96°·8	·416	·4275	– 79°
Pb-Zn	18°·25	96°·5	·488	·434	– 79°
Zn-Arg	18°	98°·5	·730	·638	–330°
Zn-Arg	18°·5	86°·5	·718	·678	–330°
Pb-Arg	18°·6	95°·5	·682	(·636)	...

Electricity: its Relation to Vital Power.—The *Scientific American* of May 3 contains a short article on this subject, of which the following seem to be the principal points. Vital and nerve forces are assumed to be identical. The question then arises: Is there a relation between electricity and nerve force? Have they anything in common? These are questions of almost infinite importance in relation to the welfare of every human being. The electrical conditions of the atmosphere are totally unstable, changing from hour to hour, and if the force which they represent is allied to our own vital force it is impossible to resist the conclusion that the bearing of these fluctuations on the health of the whole human race must be powerful for good or for evil. It was formerly a common thing to speak of the "electric fluid." This term was used because the mysterious agent could be conducted from one place to another; it would *run* as water does in a pipe; it was produced in one place and run along to another, following certain substances which were called conductors. Nerve force does precisely the same thing. It originates only in the nerve cells, minute microscopic objects, which, however, are in many places grouped into such masses —called ganglia—as to be of appreciable size. These, from their colour, are called the grey matter of the nervous system, while the cords which we know as nerves running to every part are white. These nerves are simply the conductors; they originate nothing, any more than do telegraph wires. Here is the first similarity of nerve force to electricity; it is found in the battery (the nerve cell), and is connected by the wire (the nerve). The second item of similarity is that electricity directly applied to a nerve produces the same effect as an increase of its own force. The muscles are under the control of the will. My mind, for instance, determines to bend my forefinger; the brain cell sends the message by means of the nerve to the appropriate muscle, and my finger is bent. If now, on the contrary, I apply a battery to that same nerve, the finger is at once bent, without my will, or even in opposition to my will. Apparently I send the *same force* from the battery that the brain sent in the other case, and as I can easily make the battery the stronger of the two, the finger is bent even though I determine that it shall not stir. This is one strong proof of the absolute identity of the two forces. Still again, in studying the action and functions of the sympathetic nerve or system, it is found beyond question that the direct application of electricity increases the power of action of the part to which it is applied. It is found, on the other hand, by clinical observations that whatever tends to exalt the nerve force does precisely the same thing; that is, nerve force and electricity produce the same results, as was the case in the previous illustration. It would seem, therefore, that electrical force and nerve force must be identical; but there are, on the other hand, points of discrepancy which must not be neglected. The mode of distribution is widely different. It is a matter of great difficulty to retain electricity after we have produced it. It escapes with exceeding ease, and the most careful insulation will hold it but imperfectly, especially where moisture can reach it. Nerve force, on the contrary, originates among the moist tissues, and passes everywhere freely among them without any tendency to escape from the line of its own moist conductors—the nerves. It is true that this does not prove identity, for it may be only one feature, as yet imperfectly understood, of one out of perhaps several types of electrical energy; and the same remark may apply to the fact that different nerves, which so far as we know are identical in structure, convey nerve force to totally different types. We have nerves of sensation, of motion, of sight, of hearing—of all the special senses. Are these all only distinct forms of electrical action? It seems probable that from all these sources of inquiry we may draw the inference that even if electricity is not identical with our nerve force it is at all events so closely allied with it that electrical changes must surely influence human vitality, either for good or for evil.

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SOME RELATIONS OF CHEMICAL CORROSION TO VOLTAIC CURRENT.*

BY G. GORE, F.R.S., LL.D.

The chief object of this research was to ascertain the amounts of voltaic current produced by the chemical corrosion of known weights of various metals in different liquids. The research was also made to throw light upon the conditions which determine the entire conversion of potential molecular energy into external (*i.e.*, available) electric current. The method adopted was to take about six or eight ounces by measure of a corrosive electrolyte, and divide it into two equal volumes in two similar glass vessels. Two pieces of metal of equal dimensions were then cut from the same sheet, cleaned perfectly, and weighed. One of the pieces was employed as the positive plate of a voltaic cell in one of the portions of liquid, and the other as a comparison corrosion sheet in the other portion. The negative metal of the voltaic cell was in nearly all cases a large cylinder of sheet platinum, and surrounded the positive one; in No. 24 it was a large cylinder of lead. The positive and comparison plates were wholly immersed in the separate portions of liquid, except that the former had a narrow exterior projecting strip for connection in a circuit. The current from the cell was passed by means of a small silver anode (½in. by ⅜in.), and a smaller silver cathode (¼in. by ⅜in.) in a third vessel, through a cyanide of silver plating solution containing the least practical proportion of free potassic cyanide in order to obtain the maximum amount of silver deposit.

During each experiment observations were made of any liberation of gas or formation of solid coating upon the plates, and of any other circumstance which appeared likely to affect the speed of corrosion, or weight of the plates, or of the deposited silver; and in any case where any solid coating was found, it was entirely removed after the experiment, and previous to ascertaining the losses of weight by corrosion. After the experiment the plates were well washed and carefully dried between hot sheets of filter-paper before weighing. The metals and liquids employed were as pure as could conveniently be obtained, and distilled water was used for all the solutions. The sample of potassic cyanide usually employed was found by analysis to contain 89·14 per cent. of the actual substance; but that used in Nos. 1, 2, and 90 contained only 81·7 per cent. Nearly all the liquids were employed at the atmospheric temperature, and in every case except Nos. 40, 41, 56, and 57, the comparison sheet was used.

As the proportion of silver deposited to the amount of external current generated, and therefore also to the amount of positive metal corroded, varied to a very small extent with the density of the current at the cathode in the depositing solution (*see* "Electrolytic Balance of Chemical Corrosion," *Proceedings* Birm. Phil. Soc., Vol. III., 1883, pp. 278-304), the amount of cathode surface was usually varied according to the apparent strength of the current and rate of deposition, being smaller as the current was less.

The degrees of electromotive force were measured by the aid of two thermo-electric batteries, each consisting of about 300 pairs of iron and German silver, together with a Clark's Standard cell (see *Proceedings* Birm. Phil. Soc., Vol IV., Part 1; also *The Electrician*, Vol. XII., p. 414).

The accompanying series of tables exhibit the results. In the tables the number of square inches given includes in each case both surfaces of the immersed portion of the positive metal; and similar with the comparison plate. The losses of the plates and the weight of deposited silver are in every instance expressed in grains, and the rates of loss of the positive plate are given in column 6 in grains per square inch per hour. If the whole of the corroded portion of the positive metal produced external current consistent in amount with the atomic weights and valencies of the metals as given in the tables, and if that amount be called 100, then the proportions of such current actually obtained in the experiments are those given in column No. 9. The quantities of substance mentioned in column No. 1 were in each case per ounce of water.

* Read before the Royal Society, February 21, 1884.

	1	2	3	4	5	6	7	8	9
No. of Exp.	Voltaic Elements.	Sq. Inches.	Hours.	E.M.F. in Volts.	Loss by positive Plate.	Rate of Loss.	Loss by Comparison Plte.	Wt. of Slvr. Deposited.	% of equiv. of current.
	Mg″=24·3.								
1	10 grains KCy	1·5	3·	1·095	·028	·006	·013	·220	88·42
2	10 ,, ,, ...	3·	5·	1·095	·042	·002	·006	·355	95·10
3	10 ,, ,, ...	1·5	17·	·9046	·010	·0004	·003	·062	69·75
4	1¼ minims HNO_3..	,,	2·	1·933	·577	·192	·560	·384	7·45
5	,, ,, HCl ...	,,	1·	2·000	·378	·252	·378	·183	5·45
6	⅛ ,, H_2SO_4.	,,	1·5	2·216	·081	·036	·109	·298	41·10
7	1¼ ,, ,, .	,,	½	variable	·168	1·344	·183	·070	4·68
8	10 ,, $HFSiF_4$.	,,	·5	2·111	·257	·343	·116	·910	39·83
	Zn″=65.								
9	100 grains KHO ...	4·	4·	1·243	1·620	·101	·563	·909	16·88
10	10 ,, KCy ...	3·	1·5	1·085	·188	·042	·051	·484	77·45
11	100 ,, ,, ...	4·	5·	1·1435	1·410	·0705	·391	2·996	64·00
12	1¼ minims HNO_3..	3·	·5	1·2726	·461	·307	·343	·137	6·45
13	5 ,, HCl ...	,,	1·	1·185	1·142	·381	·482	·790	20·81
14	30 ,, ,, ...	4·	·5	1·225	1·334	·667	2·379	·354	8·10
15	1¼ ,, H_2SO_4...	3·	·5	1·117	·389	·259	·113	·283	21·90
16	10 ,, $HFSiF_4$.	4·	2·	1·156	·399	·050	·250	·639	48·70
	Amalgamated Zn.								
17	10 grains KCy......	3·	2·	1·121	·360	·060	·077	·930	77·70
18	100 ,, ,, ...	,,	3·	1·236	·599	·066	·082	1·418	71·25
19	5 minims HCl......	,,	4·	1·220	·887	·074	·038	2·670	90·55
20	1¼ ,, H_2SO_4...	,,	3·	1·111	·609	·067	·060	1·658	81·90
21	1¼ ,, ,, ...	,,	1·	1·111	·184	·061	·001	·513	83·90
22	20 ,, ,, ...	,,	2·	1·2536	·856	·143	·049	2·599	91·35
23	*100 ,, ,, ...	,,	3·	1·4407	1·166	·129	·076	3·488	90·02
24	100 ,, ,, ...	,,	6·	·5098	·504	·028	·076	1·175	72·84
	Cd″=112.								
25	10 grains KCy	3·	16·	·8019	1·759	·036	·116	2·982	84·97
26	100 ,, ,, ...	4·	7·	·987	·720	·023	·021	1·264	91·00
27	1¼ minims HNO_3..	3·	1·	1·0426	1·250	·417	·808	·393	16·30
28	5 ,, ,, ..	,,	·5	·9622	2·129	1·42	5·090	·145	3·53
29	5 ,, HCl.........	,,	4·	·948	·541	·045	·041	·803	77·00
30	50 ,, ,, ...	,,	3·	1·017	1·040	·115	·061	1·783	88·85
31	1¼ ,, H_2SO_4...	,,	2·	·862	·576	·096	·123	·839	75·50
32	50 ,, ,, ...	,,	3·	·9774	·814	·090	·323	·988	63·00
	Amalgamated Cd.								
33	10 grains KCy ...	,,	15·	·739	2·118	·047	·153	3·583	87·45
34	100 ,, ,, ...	,,	6·	1·033	·769	·043	·046	1 378	92·90
35	50 minims HCl...	,,	5·	1·058	1·048	·069	·054	1·846	91·40
36	50 ,, ,, ...	$\frac{1}{16}$	,,	1·058	·434	1·38	·004	·783	93·69
37	1¼ ,, H_2SO_4 ...	3·	4·	·7463	·519	·043	·035	1·857	85·60
	Sn″=118.								
38	100 grains KHO ...	5·	6·	·9552	·592	·0197	·059	·942	86·90
39	1¼ minims HNO_3..	4·	5·	·8333	·882	·0441	·733	·036	2·23
40	Pure HF of 3·5 p.c.	5·	,,	·6872	·420	·017	—	·545	70·77
41	,, ,, 14·0 ,,	,,	4·	·7411	·383	·019	--	·551	78·59
42	20 minims HCl ...	,,	5·	·7514	·205	·008	·054	·219	58·35
43	40 ,, ,, ...	,,	7·	·7514	·323	·009	·070	·433	73·42
44	50 ,, ,, ...	4·	,,	·8627	·375	·013	·077	·654	95·25
45	60 ,, ,, ...	5·	7·	·833	·370	·0106	·064	·533	78·70
46	½oz ,, ...	,,	4·	·863	·419	·0209	·111	·493	64·25
47	10 grs. chrom. chlor.	,,	,,	·6354	·105	·005	·062	·119	61·90
48	16 minims H_2SO_4...	4·	7·	·756	·318	·0113	·061	·398	68·35
49	,, ,, ...	,,	15·	·756	·334	·0055	·098	·228	37·30
	Amalgamated Sn.								
50	100 grains KHO ...	2·	,,	·9847	1·313	·0437	·127	1·933	80·45
51	1¼ minims HNO_3..	,,	2·	·8689	·061	·015	·036	·086	77·01
52	50 ,, HCl ...	,,	6·	·8085	·278	·023	·066	·328	64·45
	Pb″″=207.								
53	5 grains KHO ...	4·	6·	·5797	·950	·039	·244	·781	39·39
54	50 ,, ,, ...	,,	,,	·6196	·980	·041	·179	1·807	88·33
55	100 ,, ,, ...	,,	,,	·6524	·843	·035	—	·722	41·04
56	10 ,, KCy ...	,,	5·	·3037	·046	·0023	·027	·069	71·85
57	100 ,, ,, ...	,,	,,	·2879	·245	·0122	--	·063	12·32
58	5 minims HNO_3	,,	,,	·9788	1·640	·082	1·247	·228	6·65
59	50 ,, ,, .	,,	2·	·9816	11·966	1·496	10·694	1·430	5·72
60	5 ,, HCl ...	,,	6·	·701	·469	·019	·423	·196	20·25
61	1oz. str. acet. acid.	,,	3·	·5771	·277	·023	·155	·127	21·95

* The negative plate was composed of lead.

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No. of Exp.	1 Voltaic Elements.	2 Sq. Inches.	3 Hours.	4 E.M.F. in Volts.	5 Loss by positive Plate.	6 Rate of Loss.	7 Loss by Comparison Plte.	8 Wt. of Slvr. Deposited.	9 % of equiv. of current.
	Amalgamated Pb.								
62	50 grains KHO ...	,,	6·	·6244	1·181	·049	·135	1·048	42·52
63	1 oz. str. acet. acid.	,,	4·	·6444	·331	·0207	·122	·197	28·50
	Al‴=27·5								
64	4 grains KHO ...	5·	1·	1·5117	·499	·083	·492	·499	8·43
65	10 ,, KCy......	6·	3·	1·2146	·118	·006	·333	·924	66·50
66	Pure HF. 3½ per cent. solution ...	5·	·25	·9306	1·073	·858	1·003	·219	1·73
67	50 minims HCl ...	,,	·5	1·048	1·079	·43	1·254	·189	1·50
68	1¼ ,, H_2SO_4.	,,	8·	·594	·036	·0009	·022	·262	65·10
69	16 ,, ,,	,,	7·	·736	·074	·002	·036	·556	71·66
70	16 ,, ,,	,,	17·	·736	·127	·0015	·039	1·074	72·08
71	48 ,, ,,	,,	5·	·6938	·051	·002	·020	·394	65·56
	Fe⁗=56·								
72	1¼ minims HCl ...	2·	3·	·687	·099	·016	·056	·169	22·10
73	5 ,, ,,	,,	4·	·918	·252	·031	·071	·650	33·42
74	1¼ ,, H_2SO_4.	,,	2·	·7473	·142	·035	·051	·256	26·70
	Ni⁗=59.								
75	50 grains KCy ...	3·	8·	·4001	·293	·009	·080	·791	36·82
76	160 minims HCl ...	,,	,,	·449	·106	·004	·056	·113	14·56
77	1¼ ,, H_2SO_4 ...	,,	15·	·2311	·147	·003	·038	·274	25·45
	Cu″=63·5								
78	10 grains KCy ...	6·	1·	·9706	·240	·040	·172	·123	15·05
79	100 ,, ,, ...	,,	1·	1·1758	·530	·088	·190	·577	32·00
80	25 minims HNO_3.	,,	21·	·4946	2·550	·020	·763	5·420	62·45
81	50 ,, ,, ...	,,	3·	·6429	·746	·041	·899	1·858	73·20
82	48 ,, HCl ...	4·	19·	·466	·510	·007	·181	·463	26·65
83	160 ,, ,, ...	,,	18·	·3982	·384	·005	·125	·320	24·50
84	160 ,, $HClO_3$...	6·	4·	·6872	1·416	·059	1·109	·449	9·30
85	1¼ ,, H_2SO_4...	,,	17·	·3111	·170	·0016	·109	·079	13·65
86	48 ,, ,, ...	,,	19·	·2947	·150	·001	·133	·156	21·30
87	Concentrated ,, ...	3·	7·	·4729	·075	·004	·017	·047	20·61
	Amalgamated Cu.								
88	10 grains KCy ...	6·	3·	·7368	·422	·023	·140	·502	34·95
	Ag=108.								
89	10 grains KCy......	5·	3·	·4483	·219	·015	·057	·149	68·00
90	50 ,, ,, ...	5·5	7·	·570	1·021	·026	·274	·441	43·19
91	50 minims HNO_3..	,,	6·	·4744	·815	·025	·011	·421	51·60
92	Concentrated HCl.	,,	8·	·5639	·120	·003	·038	·054	45·00
93	1oz. $HClO_3$	,,	7·	·1342	·228	·006	·000	·088	38·60
94	Cncntrtd. H_2SO_4..	,,	3·	·5007	·101	·006	·025	·073	78·20
95	Weak solution of ferric sulphate ...	,,	5·	—	3·230	·116	3·026	·043	1·30
	Amalgamated Ag.								
96	10 grains KCy......	5·75	4·	·4146	·240	·0104	·129	·116	48·00
97	50 minims $HNlO_3$.	,,	6·	·4357	1·516	·046	·000	·927	61·10

Only those results which appeared reliable are inserted in the tables; many uncertain ones are omitted. In some cases coatings of solid matter formed either upon the positive or comparison plates, or gas was evolved by the plates. Cases in which the coatings could not be perfectly removed were rejected. With magnesium in solutions of ammonic, potassic, or sodic chloride, potassic bromide or iodide, a solid deposit containing black suboxide of magnesium formed upon the positive plate only (see *Proceedings* Birm. Phil. Soc., Vol. IV.) And with aluminium in solution of iodic acid a compound of iodine was absorbed, and both the plates increased about 16 per cent. in weight (*ibid.* Part 1., p. 65). In seven cases (Nos. 6, 7, 14, 28, 65, 67 and 81), from causes which were not very apparent, the comparison sheet lost weight more than the positive one. The considerable degree of variability of rate of ordinary corrosion detracted greatly from the usefulness of the comparison plate.

The results show that the proportion of loss of the positive plate by "local action" to that by corrosion attending external current varied greatly in different cases; with silver in a dilute solution of ferric sulphate the latter only amounted to about 1·3 per cent. of the total corrosion, whilst with tin in weak hydrochloric acid it was as much as 95·25 per cent. In no instance was the whole of the metal dissolved by "local action," and in no case was the whole of the corrosion attended by external current.

The amount of corrosion of the positive plate was in nearly all cases greater than that of the comparison one. Six cases were selected from the table, in which the apparent corrosion of the latter sheet was the greatest, and some trouble was taken to ascertain by experiment whether either of these was a real one. After varying the conditions of the trial in several ways with pure copper in a mixture of 50 minims of pure nitric acid per ounce of distilled water it was found that in this instance the comparison plate was always corroded the fastest.

As the amount of corrosion of the positive plate was in nearly all cases greater than that of the comparison one, and the proportion of gas to corrosion was also frequently less with the former than with the latter, a solid deposit was usually more readily formed on the positive plate than upon the comparison one, and the chemical products were not always exactly the same upon the two plates. An instance of this kind occurred with amalgamated silver in a solution of potassic cyanide; the positive plate alone became brown. As the chemical products of "local action" and of corrosion attended by external current are usually the same; in cases where they are different, though resulting from the same materials, the total expenditure of potential molecular motion would probably be different, because the quantities of residual molecular energy of the ingredients would not be the same.

The proportion of corrosion of the positive plate accompanying external current to that produced by "local action" may be approximately arrived at, either by deducting from the total amount of corrosion of that plate the loss by weight of the comparison one, or by calculating from the quantity of deposited silver, together with the atomic weights and valencies of the positive metal and of silver, the amount of the positive metal required to produce the current. Each of these methods, however, is imperfect; the second is usually much the least so. In several cases, by employing the former one, the amount of deposited metal was found to be nearly equivalent to the amount of corrosion accompanying external current, after making allowance for a small deficiency of deposited silver caused by a portion of the current traversing the free potassic cyanide in the depositing liquid.

That the external current affects in some cases the amount of "local action" was shown by the following experiment:—A sheet of platinum and one of ordinary zinc, not connected together, were partly immersed in dilute sulphuric acid, until a moderate stream of gas arose from the zinc. On now connecting the two plates together by means of a wire, the stream from the zinc was conspicuously diminished. The contact of a negative metal with the positive one usually increased the total loss by corrosion, whilst it commonly decreased that caused by local action.

The results contained in the table further show that the proportion of corrosion attending external current (as measured by the amount of silver deposited) to that by "local action" depends upon several conditions:—1st, upon the kind of metal; thus it was usually greater with cadmium (average 75·63 per cent.) than with copper (30·33 per cent.). 2nd, upon the kind of liquid; it was greater with solution of potassic cyanide (average 63·27 per cent.) than with dilute nitric acid (31·14 per cent.). And 3rd, upon the degree of concentration of the liquid; a greater strength of solution frequently increased, and as frequently decreased, the proportion of corrosion accompanying external current to that by "local action." A variation of kind of metal also was attended by a greater change in the proportion of such corrosion than a variation of kind of liquid. This latter circumstance is consistent with the view that the potential molecular activity of metals is usually greater than that of electrolytes. (*See* "Relations of Heat to Voltaic and Thermo-electric Action," *Proceedings* Royal Society, No. 228, 1883, Vol. 36, p. 50; also *The Electrician*, Vol. XII., p. 277.)

The effect of amalgamation of the plates upon the proport tions of those actions to each other was usually distinct. In

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ten cases it increased, and in five decreased, the proportion of external electric current to "local action" currents. With tin in dilute nitric acid it greatly increased the proportion of external current to total corrosion, whilst with lead in a solution of potassic hydrate it had the opposite effect. It appeared to increase that proportion the most in cases where much hydrogen was evolved, as with zinc in dilute sulphuric or hydrochloric acid. In seven instances it increased, and in nine decreased the rate of total corrosion of the positive plate, and the amount of the latter was nearly five times that of the former; and in seven instances it increased and in eleven decreased the loss of weight of the comparison plate, and the amount of the latter was fourteen times that of the former.

The rate of total corrosion of the positive plate appeared to be related to the degree of electromotive force. By comparing together columns 4 and 6 of the table it was found that the instances of least electromotive force and lowest rate of corrosion coincided in the case of magnesium, zinc, tin, aluminium, iron, nickel, and copper; and of greatest coincided in the case of lead and copper. With magnesium the order of electromotive force was almost the same as that of total corrosion, and with copper it was partly so. No. 24 in the table further illustrates the influence of decreased electromotive force.

The simple and chief explanation of the great variation in the proportion of corrosion by "local action" to that attended by external electric current appears to be difference of electric-conduction-resistance. Where there is no external current, and the external resistance is infinite, as in cases of deposit of metal or hydrogen by simple immersion, the whole of the electricity flows through the local circuits, and deposits its complete equivalent of metal, hydrogen, or both, on the negative parts of the positive plate; but when the external resistance is least, and the resistance to circulation of local currents is greatest, nearly the whole of the electricity passes through the external circuit, and nearly the whole of the deposition of hydrogen or metal occurs upon the negative plate. In either case the full equivalent of electricity circulates. With zinc and platinum in dilute sulphuric acid the "local action" was diminished by closing the circuit. By diminishing also the external resistance in relation to that in the battery by the employment of two voltaic cells in series instead of one (see No. 23) in a separate experiment the proportion of silver deposited was increased from 90·02 to 93·83 per cent. of the theoretical quantity.

Rate of corrosion depends chiefly upon the particular combination of metal and liquid, and is limited by the substance of weakest molecular action. Thus the rates of corrosion of magnesium in solution of potassic cyanide (or in dilute hydrofluoric acid) and in dilute sulphuric acid are just the opposite of those of aluminium in the same liquids. Whilst magnesium dissolves very slowly in the former liquid and very rapidly in the latter, aluminium does just the reverse (*see* "Relations of Heat to Voltaic and Thermo-electric Action," *Proceedings* Roy. Soc., Vol. XXXVI., p. 50, 1883); therefore either a difference of metal or of liquid in this case reverses the effect. Two of the most extreme cases of difference of rate of corrosion observed at 60° F. were aluminium in 3½ per cent. pure hydrofluoric acid, and in very dilute sulphuric acid.

FROM AMERICA.—The Edison Electric Company at Brockton is trying the experiment of out-door lighting, by placing clusters of three 32 candle-power lights on a couple of street corners. The lights are suspended on wires about 30 feet from the ground. It is thus intended to demonstrate that street lighting by this system is possible.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending May 16, 1884, were £2,751, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The receipts of this company for the week ended 16th May amounted to £3,499.

LITERATURE.

A Practical Treatise on Electric Lighting. By J. E. H. GORDON, B.A. [London: Sampson Low, Marston, Searle, and Rivington, 188, Fleet-street.]

In 1878, carrying introductions to the late Count du Moncel, the writer went to Paris to see the world's fair—in the shape of an international exhibition. Electricity did not play a very important part in that exhibition, but Paris, with the aid of Jablochkoff, showed the nations that a more brilliant light than gas could be given in her streets. Talk as we may, dispute as we will, to Paris and to Jablochkoff do we owe the germs that have grown so rapidly till the whole civilised world is permeated with thoughts about the electric light. The progress made in the art of electric lighting in six short years is far greater than the progress made in a similar period by any other application of science. Midway between then and now came the Electrical Exhibition at Paris in 1881, when the world first realised the probabilities centering around the new method of lighting. The period which has elapsed since 1878 has witnessed a new literature—the literature of electric lighting. If we may venture to entertain an opinion, a proceeding which is somewhat novel in these days when mankind follows the example of "parrots" and jabbers the same old tale over and over again, we may say that while Fontaine's book introduced a certain class of literature, Gordon's book may be expected to introduce another class. In the one case we had milk—now we have meat.

Before proceeding to indicate the contents of this book we may call attention to some remarks in the preface. Mr. Gordon says:—"In October, 1881, I wrote in the *Quarterly Review*, 'The day will come when gaslight will be as obsolete as wooden torches, and when in every house the incandescent lamp will have replaced the gas jet.'" He continues "In this, the darkest hour of electric lighting, when failure after failure has occurred, when company after company has become bankrupt, I unhesitatingly repeat this—I will not say opinion, but conviction, only adding to it my further conviction that the day of universal electric lighting is not even in the near future, but in the immediate future." We refer to these words because another opportunity is afforded us of emphatically supporting Mr. Gordon's contention. We cannot be accused of over sanguineness as to the success of companies. We do not profess to be masters in the art of City intrigue and mystery, but we can see that the very failure of company after company has been and will be one of the causes of the ultimate success of electricity. To discuss this would, however, lead us away from the immediate object of this article. The book is written by one who has had to study the problem of electric lighting from a practical standpoint, and thus it touches more or less fully upon parts of the subject that have hitherto been wanting in text books. A clear and concise chapter deals with the relation of electrical units to each other and to heat and work units. The worker should be as familiar with this and the following chapter on circuits as the schoolboy with his multiplication table; in fact, we have here the fundamental formulæ required for almost all ordinary electric light calculations. Not only are the formulæ given, but also examples fully worked out. Unfortunately, though Congresses meet, discuss and define units, the multitude continues for some time in the old ways, and so we get confusion. Thus H.P. English is not the same as H.P French, and the reader has to remember two constants when one should suffice. The latter part of the chapter on circuits treats of the H.P. wasted in a system of street-mains, and formed the subject of a paper before the Society of Telegraph Engineers on December 13th, 1883. A description is given of the instruments required in obtaining measurements in electric light operations, such as Siemens' dynamometer, Thomson's reflecting galvanometer, graded galvanometer, &c., Ayrton and Perry's ammeter, and other instruments. The various incandescent lamps, their peculiarities, and the details of their manufacture are discussed in Chapter VI., while the next chapter deals with

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certain forms of arc lamps. Among the arc lamps the newest form of the "Crompton and Crabb," called the D D or double differential lamp, is described as follows:—

"The latest type of lamp* made by Messrs. Crompton and Co. is known as the D D (double differential) lamp. It also is the joint invention of Messrs. Crompton and Crabb, and shows a marked improvement on the older forms in point of simplicity of construction and also in regulation. This latter is effected by a brake wheel driven by the rack rod attached to the upper

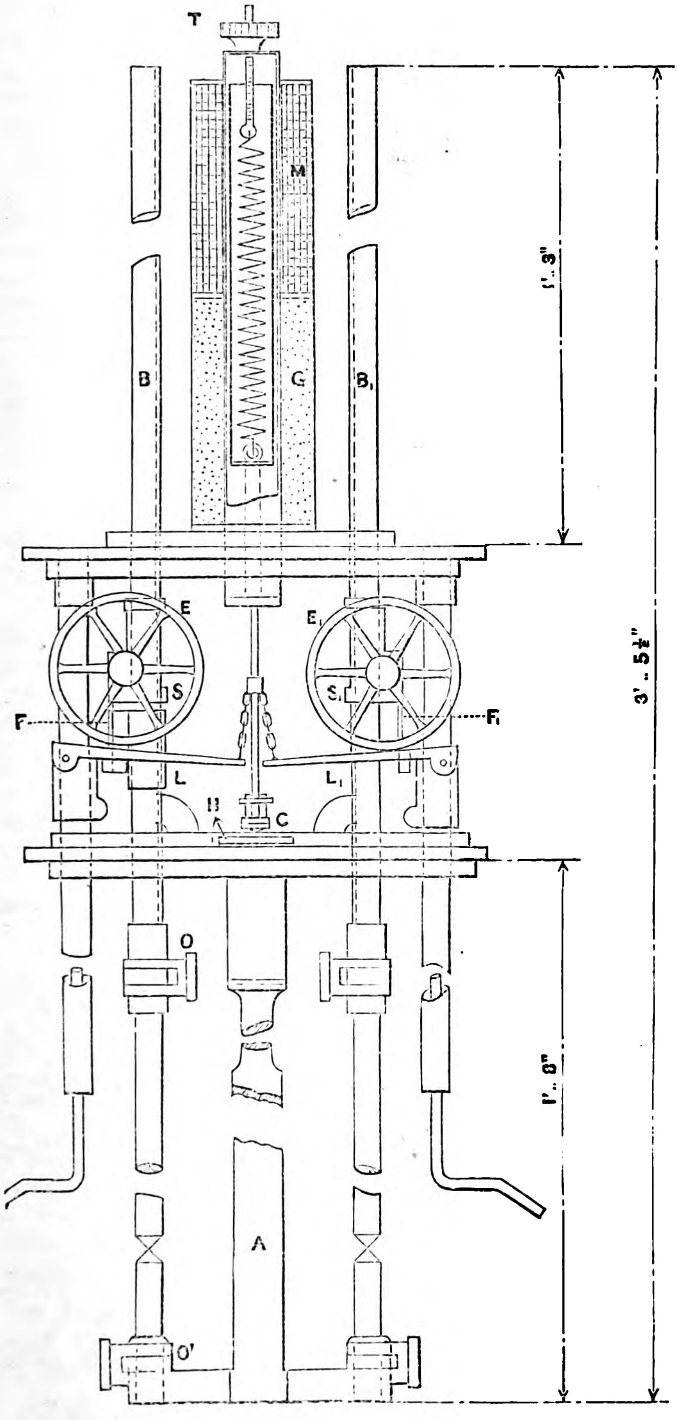

PLATE XII.—Crompton's D D Lamps.

carbons, as in the 1881 pattern, over which, however, the D D, in common with the K lamp, possesses the great advantage of being able either to increase or decrease the length of arc as may be necessary, whereas the older lamp could only decrease it. In the D D lamp also the intermediate gearing between the brake-wheel and the pinion driven by the rack rod is dispensed with. Referring to Plate XII., B and B_1 are the rack rods carrying the positive carbons. Sliding on each of these is a light gun-metal sleeve, S S_1, carrying spindles, to which are attached the two large brake-wheels E E_1, and between them the pinion which gears into the racks. To each side rod is pivoted a broad lever, L L, at the other end of which a chain is fastened, connecting it to the hollow core of the solenoid vertically above. This solenoid is differential, as in the K lamp, G being the shunt and M the main coil, and has its core partially supported by a spring, whose tension can be regulated by means of the screw T. Projecting vertically downwards from each sleeve to a distance from the centre of the spindle about equal to the radius of the brake wheels is a stout pin or finger, F F_1, the use of which we will try to make clear. Suppose the rack rod to be drawn up, then, if the lever be pulled by the solenoid above the horizontal position, the whole weight of the rod and carbon is supported on the edges of the two brake-wheels, and the friction of them on the surface of the levers is sufficient to prevent their revolution; hence this rack rod cannot run down. But if the levers be below the horizontal, then the weight is carried by the finger projecting from the

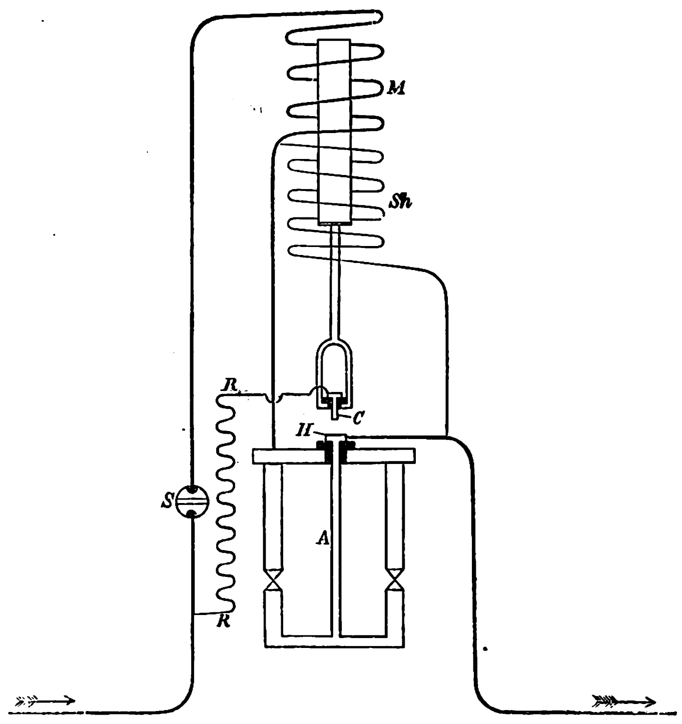

FIG. 49.

sleeve, as shown at F, the wheels are free to turn, the rack runs down, and continues to do so until the positive and negative carbon points come in contact. Now let the current be switched on by its passage through the main wire of the solenoid, the levers are raised, striking the arc, and at the same time applying the brake to the wheels. The shunt current then flows, and the arc takes its proper length. If this becomes too great, the increased current through the shunt draws down the core and levers, the brake-wheels are left free to revolve if the arc shortens. On the other hand, if the carbon points be too close, the levers are raised, bringing with them the rack rod and upper carbons. Making the finger projecting from one sleeve longer than that from the other determines which pair of carbons shall begin to burn first, because, on switching on, that pair which has the longer pin will be the last to break contact, and will therefore originate an arc in so doing. It will be easily seen from Plate XII. that on the core being raised the lever L_1 will apply the brake before the lever L does, hence it may be said that the rack rod B_1 gets a start on B; its carbon points are separated before those of B, and are kept a greater distance apart until the latter are consumed. When this is the case the rack rod B_1

* We are indebted to Messrs. Sampson Low and Co. for the illustrations to this notice.—Ed. *E.*

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is prevented from further fall by a stop, and can no longer feed; hence the arc will lengthen, the shunt current will increase, and the other rod B_1, which can still feed, will be allowed to descend until its carbons touch, starting a fresh arc. The core is raised again, the fresh arc burning instead of the old one, and everything goes on as before. When the second pair of carbons has burned low, the same action takes place, viz., further descent of the rod is prevented, the arc lengthens, the shunt current increases, and the core is drawn down, but lower than when the first pair of carbons were burned out, until a copper stud, C, attached to it makes contact with another, H, connected to the negative pole, cutting the lamps out of the circuit, and introducing an equivalent resistance. Connections of the lamp and its equivalent resistance coil are shown in Fig. 49, page 33. The current entering in the direction of the arrow finds two paths open, the one through the resistance coil R R and insulated contact piece C, which for the time being is resting upon H, and thus on to the next lamp; and the other through the switch S, which we suppose to be closed, the main solenoid, coils M, the framework of the lamp, the positive carbon, the negative carbon, and ultimately out by H, and on to the next lamp. The latter portion of the current in passing round the core magnetises it, and draws it up, thereby breaking contact between C and H. In this moment the current has only one path open, viz., that through the switch S, main solenoid, and carbons; and since the whole of it must pass through the main solenoid, the core of the latter is definitely drawn up, lifting the two rack rods, and establishing the arc between one pair of carbons, as explained above. If, through the falling out or breaking of a carbon or hanging up of the rack rods the current should be interrupted, then the core of the solenoid will instantly fall, and, by bringing C and H again into contact, open to the current the former path through the resistance coil. In this manner an accident to one lamp does not affect the other lamps burning in series with it on the same circuit. The same result will follow if the current be interrupted through the opening of switch S, and the lamp thereby be switched out of circuit. When fitted with the full length of 19½in. of carbon 13mm. in diameter, the lamps will burn from twelve to sixteen hours, according to the current passing, which may vary from 6 to 28 amperes, the light varying from 850 to 6,500 candles, the candle-power being measured at an angle of 30deg. below the horizontal line, cutting the arc itself. The electromotive force required is 50 to 60 volts."

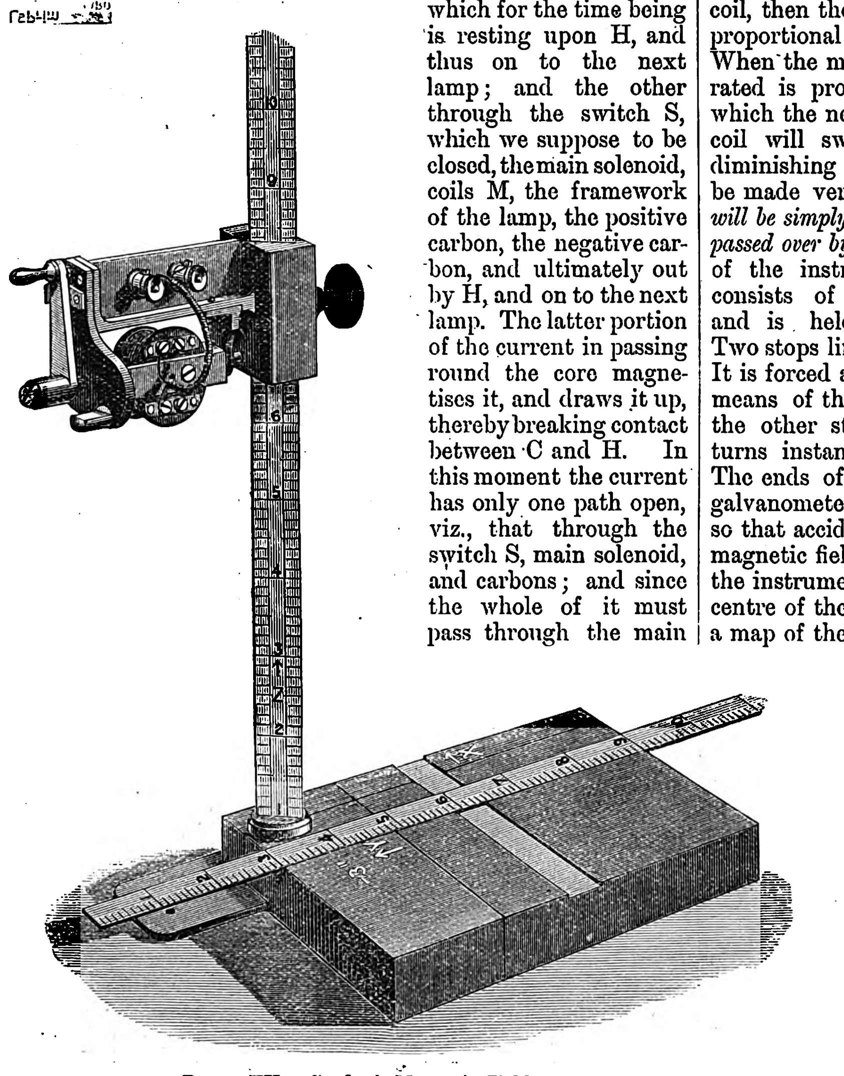

Plate XV.—Gordon's Magnetic Field Measurer.

Completing this portion of the work is a chapter on "Carbons for Arc Lamps," for which the author credits Mr. Crompton.

The latter half of the book is devoted to the consideration of machines for the generation of the electric current, and an appendix containing a number of useful tables. In the early portion of this part is discussed the theory of the generators, and among other interesting information is the description of an instrument designed by the author to measure the intensity of a magnetic field. This instrument has been described to the Society of Telegraph Engineers :—

"The principle on which the apparatus works is that if a small coil of wire, placed in a magnetic field, moves rapidly for a quarter-turn round an axis at right angles to the axis of the coil, then the total quantity of electricity generated is simply proportional to the strength of the magnetic field at the coil. When the motion is rapid, the quantity of electricity generated is proportional to the sine of half the angle through which the needle of a galvanometer connected to the moving coil will swing. By using a reflecting galvanometer and diminishing its sensibility by shunts, the angle of swing can be made very small, and then *the strength of the magnetic field will be simply proportional to the number of divisions of the scale passed over by the first swing of the light spot.* The practical form of the instrument is shown in Plate XV. The little coil consists of an ebonite bobbin wound with fine wire, and is held in a light brass frame pivoted on an axis. Two stops limit its motion, so that it can turn through 90°. It is forced against one of the stops by means of a spring. By means of the handle it can be turned till it is forced against the other stop. On the handle being released, the bobbin turns instantly through 90° under the action of the spring. The ends of the bobbin are connected to the poles of the galvanometer by means of two thin wires twisted together, so that accidental motions of the connecting wire through the magnetic field may not affect the galvanometer. The stand of the instrument is so graduated that the exact position of the centre of the bobbin in the magnetic field can be noted, and so a map of the latter can be constructed with the intensity at each point. Lines are engraved on the base from which the horizontal distances in two directions (at right angles to each other) from the centre of the magnet can be measured by the rule shown lying on at the base, and divisions in the vertical stem give the height above the face of the magnet. A gauge enables the bobbin to be set vertically over any point on the surface of the pole plate. With magnets such as are used in my alternating-current machines, the centre of the face of the pole plate is taken as 'origin,' distances measured along the circumference of the magnet-wheel are called x, those along the radius are called y, and those perpendicular to the face are called z.

"Thus such a memorandum as

$$x = 3'', y = 0, z = 4'', d = 270, c = 24 \text{ amps.},$$

would mean that at a point on the circumferential line 3 inches to one side of the centre of the magnet and 4 inches from its swing the magnetic field was such as to cause the light-spot to face over 270 divisions of the scale when the magnetising current was 24 amperes."

We remember that frequently during recent years novelists, playwriters, and professors of legerdemain have condescended to tell us "that's how it's done," and it has been left for Mr. Gordon to follow the same lines with regard to dynamo machines. He tells us that mathematicians as mathematicians are feeble folk, and unless they are mechanicians as well little will result from them of a practical character. "The mathematician working on paper is at liberty to assume conditions which cannot be satisfied in practice. . . ." The author suggests that "practical engineers should acquire for themselves such mathematical knowledge as they require. Then their mathematics will again and again assist them in their designs, and

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their practical experience will tell them when symbolic reasoning has led them to an absurd result." We agree with the author to some extent. He refers to the design of an eminent mathematician as an example to the point. We should prefer to think that the failure of hundreds of machines is due rather to the lack of working drawings than to the lack of mechanical or mathematical skill. There is too great a hurry to patent the "idea." Plans are not committed to paper, but generalities and may-be's are—that is, the inventor proposes to do this and that by this or that or a variety of ways, not one of which has formed the subject of a working drawing. The author sees the necessity of a constant appeal to drawings, as will be gathered from his remarks on page 145. It will be interesting to many to read Mr. Gordon's views regarding alternate current machines, regarding machines of a high and of a low velocity, thus getting the reasons which induced him to design his own machine.

Besides the alternate, several typical direct-current machines, such as the Bürgin, Brush, and Edison machines, are described. Mr. Gordon is very hard upon secondary batteries, contending that the only storage worthy the name "is a spare boiler full of steam, with a banked fire, and a spare engine and dynamo, kept warm, well oiled, and ready to start at a moment's notice." We beg leave to doubt the conclusions of Mr. Gordon as to the value of "secondary batteries." This is not the place to enter into a discussion, but from what we have heard of the working of the Great Western Brush Company—a company which, by the by, has been silently working and endeavouring by a rigid economy and attention to business to counteract the effects of wild speculation—secondary batteries have proved of great use. In the winter a duplicate plant is always ready; with the long days part of the plant is unused, secondary batteries forming a stand-by or a source of current before or after the engine is stopped. One more word. No difficulties have been met with in the use of such batteries, which are of the Faure-Sellon-Volckmar type. If what we have stated is correct, the facts are too strong for any business man to ignore.

The contents of Mr. Gordon's book have been thus briefly indicated. It contains many statements open to criticism, but without doubt it is the most valuable work on electric lighting that has yet appeared. It is essentially non-mathematical, readable, and practical. A word of praise is due to the publishers for the excellent manner in which the book is illustrated and produced.

Electricity: its Theory, Sources, and Appliances. By John T. Sprague, M.S.T.E.&E. Second Edition, greatly enlarged. [London: E. and F. N. Spon, 16, Charing-cross.]

The new edition of this book reaches us just as we are going to press, but as many correspondents have at various times asked for information as to its publication, we notify that it is now ready, and reserve any remarks we may have to make till after reading the work.

A Pocket Book of Electrical Rules and Tables for the Use of Electricians and Engineers. By John Munro, C.E., and Andrew Jamieson, A.M.I.C.E., F.R.S.E. [London: Charles Griffin and Co., 12, Exeter-street, Strand.]

Although this book has been in our hands but a few hours —far too few, indeed, to adequately investigate its contents— yet a cursory examination is such that it seems an imperative duty to call attention at once to its publication, and to induce every reader to obtain a copy. The plan has evidently been to produce an electrical "Molesworth," and, so far as we can judge, with great success; in fact, for a first edition it seems wonderfully perfect. No doubt the compilers will at once commence to note suggested alterations, new information, and so on for future improvement. Some errors will doubtless be found, but, except in the definitions, we have as yet failed to find any. We are not quite sure whether many of the tables had not better be relegated to the rubbish heap. It may be that we have somewhat sinned in publishing "tables" having but a tentative value, but we contend that a difference exists in the publishing of tables in a periodical and in a pocket book. The compilers, for example, might well consider the real value of the table on pp. 214, *et. seq.* Is it, in fact, of any practical value whatsoever? The answer to such a question may perhaps be given by an appeal to the writings of Forbes, Gordon, Blakesley, and others. However, we shall leave criticism for the future, satisfying ourselves that the pocket book as presented now is worthy of all the commendation we can give it.

ON THE PHYSICAL PROPERTIES OF METALS.*

BY SHELFORD BIDWELL, M.A., LL.B.

Having observed that the coefficient of the Thomson effect is generally positive in those metals which have a great specific resistance and specific heat, and negative in those which are distinguished by a great coefficient of expansion, the author endeavoured to find an empirical formula, expressing the coefficient of the Thomson effect in terms of the specific resistance, specific heat, and coefficient of expansion. Though he was not altogether successful, he believes that the subjoined table points to the existence of a close relation between them.

I. Metals.	II. Coefficient of Thomson Effect.	III. $H \times R - E^2$	IV. Last Column Divided by 2,400.
Ni	5·12	12,320	5·13
Fe	4·87	9,918	4·13
Pd	3·59	7,086	2·95
Pt (soft)	1·10	2,309	0·96
„ (hard)	0·75		
Mg	0·95	1,384	0·58
Pb	0	– 604	– 0·25
Al	– 0·39	1,942	0·81
Sn	– 0·55	– 868	– 0·36
Cu	– 0·95	– 1,137	– 0·47
Au	– 1·02	– 1,172	– 0·49
Ag	– 1·50	– 2,246	– 0·94
Zn	– 2·40	– 2,355	– 0·98
Cd	– 4·29	– 4,958	– 2·07

The first column contains the names of all the metals, except alloys given in Tait's thermo-electric diagram (*Transactions* R. S. E., Vol. XXVII., p. 125). The second column gives the coefficients of the Thomson effect. These are taken from Everett's table ("Units and Physical Constants," p. 151), which is based upon Tait's diagram.

H R and E being numbers proportional to the specific heats, specific resistances, and coefficients of expansion of the various metals, $H \times R - E^2$ gives the numbers in the third column. H = spec. heat $\times 10^3$, R = spec. res. $\times 10^3$, E = expansion $\times 10^8 \div 34$. The multipliers 10^3 and 10^8 were used merely for the convenience of getting rid of decimals; the division 34 was so chosen that while the ratio of the first number to the last in column III. should be as nearly as possible equal to the ratio of the first number to the last in column II., the number corresponding to lead in column III. should at the same time be as near zero as possible. Both conditions could not be exactly fulfilled at once.

Column IV. gives the numbers in column III. divided by 2,400, to facilitate comparison with column II.

It will be seen that with one exception the order of magnitude of the numbers in column IV. is exactly the same as the order of those in column II. The rate of decrease is not, however, the same, the numbers diminishing too rapidly in the upper half of column IV., and too slowly in the lower half.†

* Abstract of a paper read before the Royal Society, May 7th.

† With regard to aluminium it is suggested that Matthissen's determination of the specific resistance 0·029 is possibly too high. Moreover, the author found experimentally that the Thomson coefficient of the specimen of aluminium which he used was slightly + instead of – as given in column II. It is also shown as + in the diagram at p. 178 of Jenkin's "Electricity." If its specific resistance were as high as 0·026, it would come between magnesium and lead in column IV.

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THE ELECTRICIAN.

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All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

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All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes	25
Some Relations of Chemical Corrosion to Voltaic Current. By Dr. G. Gore	30
Literature. (Illustrated)	32
On the Physical Properties of Metals. By Shelford Bidwell	35
The Submarine Cable Convention	36
Correspondence. Illustrated	37
Artificial Light Tables. By A. P. Trotter. Illustrated	38
On the Field Magnets of Dynamo Machines	38
The Diameter of Conductors to Prevent Overheating. By G. Forbes. (Continued)	39
Telpherage. By Prof. Fleeming Jenkin. Illustrated	41
Legal	43
The London Platino-Brazilian Telegraph Company	43
The West India and Panama Telegraph Company	44
Maxim-Weston Electric Co.	45
The Lancashire Maxim-Weston Electric Company	46
Companies' Share List	48

VOLUME XII.

Volume XII. of "THE ELECTRICIAN" will be ready in a few days, price 10s. 6d.

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IMPORTANT NOTICE.

*** All communications should be sent to our new offices, 1, Salisbury-court, Fleet-street, E.C., where *The Electrician* is now printed and published.

THE SUBMARINE CABLE CONVENTION.

Small concessions are always more certainly obtainable by large demands than by diffidence or moderation. The provisions embodied in the Convention for the Protection of Submarine Cables, published in our last issue, are a case in point. The proprietors of these cables put forward claims which we stated at the time would never be acceded to, and which, indeed, were probably never expected to be listened to. Nevertheless, there being a good substantial case to go upon, and the applicants being powerful enough to get a hearing, valuable concessions have been made to them; and if all has not been obtained that was asked for, as much has been given as could be reasonably expected. The moral offence of injuring or destroying submarine cable property has been declared a legal offence, and proprietary rights in respect of this class of property has been fully recognised by the leading civilised nations of the world.

The cable companies will probably not regard the decisions of the International Convention of Paris as final, and no doubt something more is not only needed but will be granted at a not far distant date. But for the present it is a great achievement to have established the principles—first, of legal ownership; and secondly, of international protection. The circumstance of plenipotentiaries representing more than twenty nations of Europe, Asia and America meeting together to impose legal obligations upon each other is sufficient evidence of the latter, whilst the former is shown in the wording of the second clause of the Convention. Article II. declares that "It is a punishable offence to break or injure a submarine cable wilfully or by culpable negligence." It will be news to some people that the offence here referred to is created a punishable one now for the first time. It is one that has been committed on many occasions; sometimes, as is gravely suspected, with malicious intention, often with culpable negligence, always with confidence in immunity from punishment. We may confidently predict that motives of prudence will henceforward assist the moral sense, and so diminish the number of preventible injuries.

Besides the punishment of such offences, in a manner to be hereafter determined by the respective countries, actions for damages will be sustainable under the provisions of this Convention. Hitherto it has been difficult and perhaps impossible to bring an action for damages done to cables beyond territorial waters; and consequently the very first Article declares that the convention shall apply outside territorial waters—that is to say, to those waters outside the shore boundaries over which each country already possesses some jurisdiction. Indeed, if we understand Article I. aright, the Convention applies only to the high seas, and assumes that the municipal law of each country is competent to take care of the region included in the shore boundaries. What was needed was a territorial standpoint for places beyond the reach of municipal law; and this is provided by Article VIII., which identifies the offence with the country of the offending vessel:—"The tribunals competent to take cognisance of infractions of this Convention are those of the country to which the vessel on board of which the offence was committed belongs." Nor is the prosecution to be left to the injured parties, for Article IX. stipulates that such offenders shall be proceeded against by the State or in its name, independently of any action which cable proprietors may institute for damages on their own account. The nationality of the offending vessel is generally ascertainable; but when a ship of war is in the vicinity its officers are authorised to "demand from the captain or master the production of the official documents proving the nationality of the said vessel." Lastly the high contracting powers have engaged to take or propose to their respective legislatures the necessary measures for summarily punishing by either fine or imprisonment, or both, those who contravene the provisions of the Convention. There should be little difficulty in passing the requisite Act of Parliament to meet this engagement.

No exception will, we imagine, be taken to the conditions imposed on the other hand upon the companies themselves. In laying cables they are to be compelled to place them in positions of safety, and to construct them of proper dimensions. During the operations of cable laying, buoying, or repairing they must give due notice to fishing craft, who on their part, after due notice, must keep at safe distances from the scene of operations. Rules as regards signalling which are now in use receive an international recognition under the

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Convention, and responsibility for disregarding them, or negligently not seeing them, is thrown upon the vessel doing damage in consequence. A judicious provision enables vessels that have abandoned their anchor or tackle to avoid injuring a submarine cable to claim compensation from the owners of the cable—a provision which will greatly reduce the damage done by fishing boats on the too-often-alleged plea that to respect other people's property would have endangered their own.

On Article XV. there appears to have been some slight fear of misapprehension. It reads thus:—"It is understood that the stipulations of the present Convention do not in any way restrict the freedom of action of belligerents." It was chiefly on this point that full consideration was demanded by some of our cable proprietors. Oddly enough, it is the plenipotentiary representing this country who emphasizes the understanding in a supplementary note to this effect:—"Her Majesty's Government takes Article XV. to mean that in time of war a belligerent will be free to act . . . . as if the Convention did not exist." Nothing less was understood, we should imagine, by any of the contracting parties; for an engagement to respect cable property in time of war would certainly be broken as soon as war commenced, and no nation can afford to have its hands tied in regard to other nations' property when its own would inevitably be destroyed. Submarine cables, however, in this relation are not rightly described as property, but as aids of warfare, like ships, tunnels, land telegraphs, and railroads. The general provisions of the Convention are so beneficial for times of peace that there is no room to regret that an illusory protection was not accorded to submarine cables in time of war.

CORRESPONDENCE.

ZINC-LEAD ACCUMULATORS.

TO THE EDITOR OF THE ELECTRICIAN.

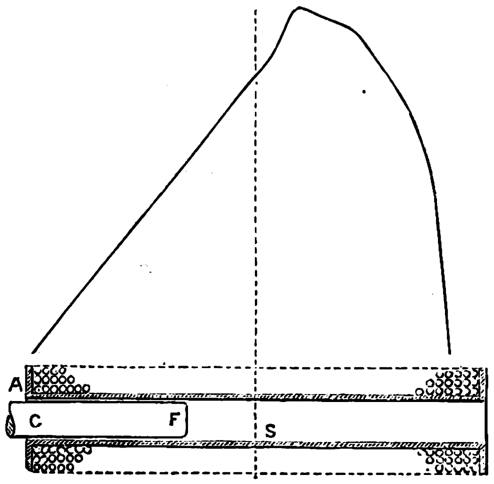
Sir: In *The Electrician* of February 9th is an interesting account of a zinc-lead accumulator. In your last edition we have some comparative results obtained with this combination, which is not new. Those not acquainted with the action of secondary batteries would very naturally conclude from these results that zinc—the king of primary batteries—would hold the same position in respect to secondary ones. Theoretically this is very nice—practically it is useless. If we take for experiment an accumulator of any of the known types, and substitute zinc plates for the existing lead ones, or what is more simple, make the electrolyte a saturated solution of zinc sulphate by charging the cell in the usual manner, we cover the negatives electrolytically with zinc. By taking out the now very acid solution, and refilling the cell with zinc sulphate as before, we then have a zinc-lead accumulator. On the second charging of this arrangement an alteration takes place. We deposit some of the zinc from the electrolyte, which has the effect of leaving it very acid, which acid has a great liking for the rough deposit of metallic zinc. This it greedily devours, liberating a quantity of hydrogen, which we know is not beneficial to the opposite pole. If we discharge the cell immediately after the charging is complete (it is difficult to tell where such is the case without an acidometer, while zinc remains in solution there is no gas disengaged), we get a powerful discharge of fully 2·35 volts, and if we rapidly discharge the cell we get a return of 97 per cent. If we let the cell rest a few days or a week the results are not so pleasing. If we fully charge a set of zinc-lead couples to-day for use to-morrow, during the night the cells will be very active. The electrolyte having given up the greater part of its zinc will contain much free acid, which acid will speedily regain its share of zinc, giving off a great quantity of hydrogen, much to the satisfaction of the peroxide of the negative element, and much to the dissatisfaction and danger of those compelled to be with or near them. The deposit of metallic zinc is very pelverulent, which necessitates a great distance between the plates to prevent contacts. There is an accumulation of dirty crystals of zinc sulphate, which does not improve the mind in the direction of trouble and economy. The use of cupric sulphate in connection with copper plates (Sutton's arrangement) is open to similar defects in a lesser degree. If we discard lead as a negative pole we are going in the wrong direction, for this pole has never been any trouble, but is simply perfection.—Yours, &c.,

H. A. Kent.

SOLENOIDAL ACTION.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Having recently made some experiments on the pull exerted by a solenoid on an iron core, we met with certain results which may perhaps be unknown to some of your readers, and we therefore venture to send a few particulars. Referring to the diagram, S is the solenoid, and C the iron core. Suppose the end F of the core to be inserted into the solenoid at A, and gradually moved through the coil. The curve shows the pull at any corresponding position of the end F. It will be noticed that the curve follows the "straight line law" until F reaches the centre of the coil; a slight dip then occurs, but the point of maximum pull is reached when the *magnetic pole of the cone is at the centre of the coil;* another



dip then occurs, and the curve gradually drops to zero. The first dip is evidently caused by the back pull of the coil on the part of the core between the end and the magnetic pole. The experiments were made with reference to our electric meter, and we devised a simple apparatus to automatically draw the curves.—Yours, &c.,

Gilbert Hammersley,
C. H. Worsey.

Birmingham, May 19, 1882.

ELECTRICAL UNITS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Is there any way of expressing these, all to one scale as it were, so as to convey some definite idea of their meaning and comparative powers? for it is hard to realise the actual effects of either the theoretical or the practical units as given in the text books. Do they not each signify either an effort or an obstacle? and if so, cannot the equivalent of each be stated in foot-pounds?

It is hardly fair to ask you to correct sums, but can you kindly explain how the formula ($C = \cdot 362\, D \tan \delta$) is derived from $C = H \tan \delta . \frac{a}{2\pi}$? (Gordon's "New Treatise on Electric Lighting," pages 40 and 41).

I make it ($C = \cdot 036\, D \tan \delta$) as enclosed; and similarly, his example on page 41 comes out ·304 instead of 3·04.—Yours, &c.,

Country Student.

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ARTIFICIAL LIGHT TABLES.—(Copyright.)

(Showing the time during which Artificial Light is required throughout the year).

BY A. P. TROTTER, B.A., A.M.I.C.E.

Table I.

The shaded area represents the time during which artificial light is required throughout the year. The horizontal lines divide the diagram into twelve months, and the vertical lines show the hours of the day and night, from 2 p.m. to 9 a.m. The inner dotted lines show the time of sunset and sunrise.

In order to ascertain the approximate time of dusk, a number of circulars were sent out to the large houses of business and to establishments where electric light has been in use for some time, asking if any record had been kept of the time of lighting up, and for information as to the frequency and duration of fogs.

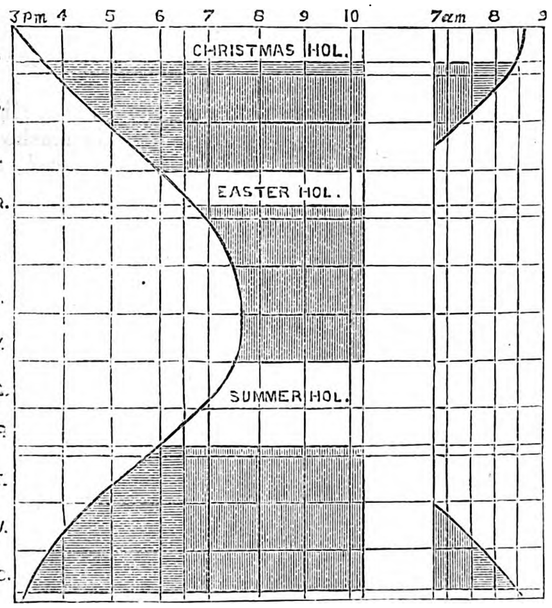

TABLE I.

The only useful answer was from the South Kensington Museum, and this was as complete as it could be. The curved lines on the diagram are laid down from an average of the daily record of the time of lighting up for the last three years. When light has been used all day on account of fog, &c., this has been taken into account and spread in the proper proportion over the foggy part of each year. The curves for the three years were taken separately, and agreed fairly well with each other, and the average was taken by interpolation. It may be noticed that November does not appear to be guilty of its proverbial amount of fog.

The time of dusk will of course be later for outdoor lighting than for indoors, and earlier for town than for country.

It may be ascertained from the diagram that if an establishment closes at half-past seven all the year round the amount of time during which light will be needed is measured by about 26 squares. Each square is an hour-month of 30·4 hours, or if Sundays and the six holidays be omitted, 25·6 hours. The time required will therefore be about 660 hours. If the time of closing be an hour later, 365 or 307 hours must be added.

The table was originally suggested in the course of reckoning the amount of light required for a large public school, the average duration of the holidays being struck out. The diagram shows at a glance, in this case, the proportion of light used in the school buildings and in the masters' houses when transferred to the latter after school hours. The time of dusk has been put back a little, being for the country.

Table II.

The shaded area represents the time during which light is required.

The horizontal lines show the months of the year.

The vertical lines show the hours of the day and night.

The inner dotted lines show the time of sunset and sunrise.

The outer lines show the time of lighting up and extinguishing.

Each square is an hour-month, *i.e.*, 30·4 hours, or if Sundays and the six holidays be omitted 25·6 hours.

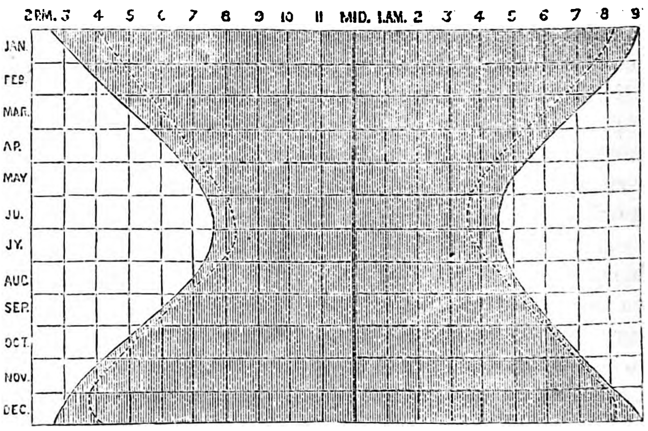

TABLE II.

If light is required from dusk till 7:30 all the year round, the total time will be about 790 hours. If Sundays and the six holidays be omitted, the total will be about 660 hours.

For every hour later add 365 or 307 hours.

ON THE FIELD MAGNETS OF DYNAMO MACHINES.

In a recent communication to the Vienna Society of Electricians Dr. A. von Waltenhofen attempted a scientific justification of F. Uppenborn's purely empirical rule for the exciting power necessary to properly magnetise the field magnets of a dynamo machine. According to this rule * the exciting power should be proportional to the cross-sectional area of the field-magnet cores, the proportion being 110 ampere turns for every square centimetre of core area. In English measure this gives about 700 ampere turns per square inch. Without pronouncing any opinion on the practical value of this rule, which gives exciting powers by far in excess of our best modern English practice, we nevertheless think a short abstract of Von Waltenhofen's reasoning will be of interest to our readers, the more so as this subject has up to the present not received sufficient attention, and trustworthy rules for the design of field magnets are nowhere to be found.

The author puts two propositions :—

I. We can either excite the field-magnets to a certain point of magnetic saturation, thereby making the total magnetism proportional to the total weight of the field-magnets, or

II. We can excite to such a degree that the free magnetism appearing chiefly on or near the polar surfaces is proportional to the total weight of the field magnets.

Ad. 1. According to Mueller and Dub, the total and the free magnetism of cylindrical cores of equal length but different diameter excited by the same number of turns carrying the same current is proportional to the square root of the diameter.

* J. Uppenborn, "Kalender für Elektrotechniker," p. 123.

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If length and diameter vary, but in such a way that the ratio of diameter to length remains constant, we know by Sir W. Thomson's rule that similar cores similarly wound with the same size wire, the length of which is in each case proportional to the square of the linear dimensions of the core, and traversed by the same current, produce in points similarly situated equal magnetic forces.

From this law and from that giving the action of a magnet at a distance it follows that the magnetic moment of similar cores is proportional to the cube of their linear dimensions. By combination of this with the above thereom of Dub we find that the magnetic moments of cores of different lengths magnetised by an exciting power in proportion to their lengths are as the $\frac{5}{2}$ power of the length, and if magnetised by the same exciting power they are as the $\frac{3}{2}$ power of the length.

Let x be the exciting power, y the corresponding magnetic moment, l the length, d the diameter, and k a constant, then is

$$y = x.\, k \sqrt{l^3 d}\,.$$

Let y_1 be the magnetic moment for maximum saturation, and $\mu = \frac{y}{y_1}$ a coefficient denoting the degree of saturation which is produced by the exciting power x, then is

$$\mu = \frac{x\mathrm{K}.\sqrt{l^3 d}}{y_1}.$$

Now, the maximum of magnetic moment corresponding to complete saturation was shown by the author to depend only on the volume of the core,* so that y_1 is proportional to $l\,d^2$, and therefore

$$\mu = \frac{x\,\mathrm{K}}{d}\sqrt{\frac{l}{d}}.$$

For field magnets of different size but geometrically similar proportions $\sqrt{\frac{l}{d}}$ is a constant, and since K is also a constant it follows that to obtain equal degrees of magnetic saturation in field magnets of different size, the exciting power must be proportional to the diameter of the core.

Ad. II. It is therefore evident that Uppenborn's rule cannot be deduced from the condition of equal saturation. The other condition was that the free magnetism at or near the polar surfaces should be proportional to the weight of the field magnets. Dub has shown that for equal magnetising powers the free magnetism at the ends of cylindrical cores is proportional to the square root of the length; since it is also proportional to the square root of the diameter we obtain for the free magnetism

$$\mathrm{F} + x\,a\,\sqrt{l\,d},$$

x being the exciting power and a a constant. By the condition Sub. II. the proportion between free magnetism and weight of field magnets, that is, between F and $l\,d^2$, is to be constant; hence we find that $\frac{x\,a}{\sqrt{l\,d^3}}$ must be the same for different sizes of geometrically similar field magnets, a condition which can only be fulfilled if

$$x = \mathrm{A}\,d^2$$

where A is a constant coefficient.

This is, in fact, Uppenborn's rule, by which the exciting power is made proportional to the area of the core—that is, proportional to the square of its diameter.

The author concludes by saying that the above only applies to the field-magnets after the armature has been removed. With the armature in place the conditions are somewhat modified.

* Von Waltenhofen, Ueber die Grenjen de Magnetisarbarkeit Litzb. d. Wiener Akademie, 1869.

THE DIAMETER OF CONDUCTORS TO PREVENT OVERHEATING IN ELECTRIC CURRENTS.*

BY PROFESSOR GEORGE FORBES.

(CONTINUED FROM PAGE 18.)

In computing with this formula, it must be noticed that the value of R, the specific resistance, varies with the temparature. The resistance at 0° C. is 1642. At the temperature of the air (which may be taken at 20° C.) it is 1736), and at any temperature which is $t°$ above 20° C. the resistance is 1642, *i.e.*, $1 + {\cdot}0038\,(t + 20)$. This change of resistance produces a change of 15 per cent. in the current which can be carried at the higher temperatures.

The effects of temperature in altering the resistance are continually cropping up in our application of theory to practice, and the following very striking experiment is worth recording:—

I have been informed by Mr. H. Edmunds that he made experiments with wires $\frac{1}{32}$ inch diameter, flattened out to various widths, through which he passed the current from a machine, the E.M.F. being the same in all the experiments. In the form of wire $\frac{1}{32}$ inch diameter, it was heated to a bright colour; when flattened $\frac{1}{16}$ and $\frac{1}{8}$ inch width it lost luminosity; and so on until, when used in a strip $\frac{1}{2}$ inch wide, it kept pretty cool, and fairly stopped the engine. Here we see that the resistance of the wire and all the strips was the same at any constant temperature, but the surface for cooling by radiation and convection was greater with the wider strips. This explains why the wider strips were cooler than the narrower ones, and still more than the wire. Lastly, the resistance is trebled at a temperature which makes the metal barely luminous, and is enormously increased at a bright heat. Hence, in the cases where there was bright luminosity, there was high resistance and less current. The wide strip, being the coolest, had most current, and used up most work, and so stopped the engine.

In the preceding table (as in others which follow it), the current specified heats the wire to the degree stated only when steadily applied. A much more powerful current might be used for a very short time at intervals, as in signalling for railways.

The only doubt of the accuracy of the calculations can come from a doubt as to the accuracy of M'Farlane's experiments, which were made in Sir William Thomson's laboratory, or in the extensions of his results to surfaces of different dimensions. On this matter I have a few remarks to make.

1. The value which M'Farlane found for the loss of heat per second per degree difference of temperature between the metal and the enclosure increased from $t = 5°$ C. to $t = 60°$ C. in the ratio 178 : 226 for polished copper. I have used the value 178 in calculating the above table, so that the current which can be carried with the copper in any state of oxidation or dirt is certain to lie between the two values given in the table under *bright* and *blackened*.

2. The only experiments with which I can compare Mr. M'Farlane's are those by the late Mr. Nichol, published by Professor Tait in the *Proceedings* Royal Society, Edinburgh, 1869-70, p. 207. Table A gives the comparison.

A comparison of the results of M'Farlane and Nichol shows that they agree generally as well as could possibly be expected, so far as the term which depends on the first power of the temperature in the expression

$$\text{loss of heat} = \mathrm{A}\,t + \mathrm{B}\,t^2 + \mathrm{C}\,t^3 + \cdots$$

is concerned, but that in the comparatively unimportant second term M'Farlane makes B negative, and Nichol makes it sometimes positive and sometimes negative. The general conclusion is that we can trust safely to the first term, but that we must not push the application to extremely high temperatures.

3. Both the above sets of experiments were made upon masses of metal some centimetres in diameter, and the conclusion seems warrantable that with such masses my formula is accurate. I state this now, because I have next to show that the law does not extend to small masses where convection

* Paper read before the Society of Telegraph Engineers and Electricians.

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plays a more important part than radiation. My impression is that thin wires lose their heat chiefly by convection when free in the air, but larger masses chiefly by radiation.

I worked at the subject experimentally in 1881 and the following years. My results were published in the British Association *Reports* 1882; *Annales de l'Electricité*, 15th October, 1882; *The Electrician*, 1882, September, and 1883, February.

TABLE A.

Loss of heat (per sq. cm. per second per degree centigrade difference of temperature) from copper in air at atmospheric pressure in blackened enclosure at constant temperature 8° C. in Nichol's experiments, for various differences of temperature:—

Polished.			Blackened.		
Difference of Temperature.	Loss per sq. cm. per sec. per degree.		Difference of Temperature.	Loss per sq. cm. per sec. per degree.	
	M'Farlane.	Nichol.		M'Farlane.	Nichol.
Degrees.			Degrees.		
10·0	·000176	—	10·0	·000266	—
12·5	—	·000198	12·5	—	·000364
15·0	·000193	—	19·3	—	·000331
15·3	—	·000182	20·0	·000289	—
20·0	·000201	—	30·0	·000306	—
21·6	—	·000175	33·6	—	·000320
30·0	·000212	—	40·0	·000319	—
32·5	—	·000173	42·2	—	·000322
40·0	·000220	—	50·0	·000326	—
42·5	—	·000173	53·2	—	·000328
50·0	·000225	—	60·0	·000328	—
55·8	—	·000177			
60·0	·000226	—			

My first object in those experiments was to test the correctness of the following considerations:—

When a current passes through a wire that is keeping up a constant temperature, the heat developed by the current over a given length is equal to that lost by radiation, convection, and conduction. It seemed right to suppose that at a fixed temperature this cooling varies as the surface, *i.e.*, as the diameter of the wire. The heat generated by the law of Joule varies as $C^2 R$ or $\frac{C^2}{D^2}$, where C = the current, R the resistance, and D the diameter of the wire.

Whence $$\frac{C^2}{D^2} = a\,D \text{ (}a\text{ being a constant),}$$

and $$C^2 = a\,D^{\frac{3}{2}}.$$

To verify the exactness of this law, I experimented on several wires of different diameters but the same conductivity. Each wire was thinly coated with beeswax, whose melting point was 58° C., the temperature of the room being 18° C. A current was passed through one of these wires, and resistances were slowly and gradually removed from the circuit, until the current heated the wire so as to melt the wax. The angle of deflection of the tangent galvanometer was then read off, to give the intensity of the current. The same operation was repeated on the other wires, and the following table gives the results obtained:—

D	C	$\frac{C}{D}$	$\frac{C}{D^{\frac{3}{2}}}$	$\frac{C}{D^2}$
Mm.				
0·58	0·984	1·696	2·229	2·924
1·22	2·304	1·888	1·709	1·548
1·58	3·026	1·915	1·523	1·212

If $C \propto D^{\frac{3}{2}}$, the quotient $\frac{C}{D^{\frac{3}{2}}}$ should be constant for all the wires. If, as some have supposed, $C \propto D^2$, the quotient $\frac{C}{D^2}$ should be constant. If, lastly, $\frac{C}{D}$ is more nearly constant, as is seen to be the case, the law is that the current varies more nearly as the diameter.

Within the last few days I have come across some tests which I had made in 1881, on five thicknesses of lead wire, to find the current required to fuse them. I found that this depended upon the length of the specimen. The reason is that the ends of the wire are clamped by cold metal, which absorbs the heat, and so a greater current is carried without fusion with short specimens than with long ones. I give the results for what they are worth.

Fusing Currents for Lead Wires.

Diameter.	Length.	Fusing Current.	Diameter.	Length.	Fusing Current.
Mm.	Metre.	Amperes.	Mm.	Metre.	Amperes.
0·55	0·025	0·78	1·28	0·300	9·5
0·78	0·025	0·937	1·28	0·150	12·37
0·94	0·025	1·125	1·28	0·075	12·75
1·03	0·025	8·2	1·28	0·050	13·5
1·03	0·225	6·0	1·28	0·025	16·87

These measurements were not made by myself, and I cannot vouch for any very great accuracy. One fact which we learn from them is, that in such experiments, with wires about 1 millimetre thick, the length in experiments of this nature should be not less than 30 centimetres, or, generally, the length should be 300 times the diameter. The effect of using short wires is especially shown with the thicker ones, the experiments on which show that a large quantity of heat is carried off by thermal conduction to the massive cooling terminals.

Taking the case of a long wire, let us see how far it gives us reason to believe in the applicability of the formulæ of this memoir to practical cases. A lead wire, 1·28 millimetre diameter and of considerable length, was heated to the temperature of fusion with a current of 9·5 amperes, and one of 1·03 millimetre diameter with a current of 6·0: let us find the theoretical current required.

By referring to Problem I., we see that the heat generated per second in one centimetre length of the substance

$$= C^2 \frac{R}{\pi\left(\frac{D}{2}\right)^2} \times \cdot 24$$

where C = current in amperes,
R = specific resistance in ohms,
D = diameter.

Now R* = 19,850 at 0° C. for lead in C.G.S. units.
= 44,751 at 327° in C.G.S. units,
= ·000044751 in ohms.

The melting temperature of lead being 327° C.†, or, say, 310° C. above the surrounding air,

$$\therefore \text{heat generated} = C^2 \frac{\cdot 000044751 \times 4}{\pi D^2} \times \cdot 24 = \cdot 0000570 \frac{C^2}{D^2} \times \cdot 24.$$

Referring to M'Farlane's experiment, I find that 60° C. excess of temperature gives a loss of heat per square centimetre per second = ·01356 gramme centigrade heat units with polished copper, and that the loss is nearly proportional to the temperature. This would give ·07006 for 310° C.

The surface of one centimetre length of the first wire is

$$\pi + \cdot 128 = \cdot 402,$$

and of the second it is

$$\pi \times \cdot 103 = \cdot 324;$$

and the loss of heat is in the first wire

$$\cdot 07 \times \cdot 402 = \cdot 02814,$$

in the second

$$\cdot 07 \times \cdot 324 = \cdot 02268,$$

* Jenkin: Cantor Lectures.

† Balfour Stewart: "Elementary Treatise on Heat," p. 88.

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and this must equal the heat generated as given above, viz.—

$$= \cdot0000570 \times \cdot24\frac{C^2}{D^2}$$

$$= \cdot00001368\frac{C^2}{D^2}$$

$$= \cdot000848\ C^2 \text{ for the first wire,}$$

$$\text{and} = \cdot001290\ C^2 \text{ for the second wire;}$$

whence for the first wire

$$C^2 = \frac{\cdot02814}{\cdot000848}$$

and for the second

$$C^2 = \frac{0\cdot2268}{\cdot001290}$$

which gives us 5·8 and 4·2 amperes theoretically in place of 9·5 and 6·0 respectively, as found by experiment. This only shows that M'Farlane's constant does not apply to high temperatures, and that the loss of heat is then much greater than in direct proportion to the temperature.

The only extensive experiments on the subject, with which I am acquainted, have been made by Mr. W. H. Preece, and the results are about to be communicated to the Royal Society. He has been kind enough to show me his experimental results, in order that I might be able to bring before you a comparison with my own results.

He measured the current which was just sufficient to melt platinum wires of different sizes, and he also measured the current which is just sufficient to make wires luminous. The results obtained by Mr. Preece confirm my experiments, and show that with small wires the (current)^2 is more nearly proportional to (diameter)^2 than to the (diameter)^3

(TO BE CONTINUED.)

TELPHERAGE.*

BY PROF. FLEEMING JENKIN, LL.D., F.R.S.

In the first place, it is necessary that I should define what is meant by this word "telpherage," and perhaps that I should defend its formation. The word is intended to designate all modes of transport effected automatically with the aid of electricity. According to strict rules of derivation, the word would be "telephorage;" but in order to avoid comparison with "telephone," and to get rid of the double accent in one word, which is disagreeable to my ear, I have ventured to give the former such a form as it might have received after a few centuries of usage by English tongues, and to substitute the English sounding "telpher" for "telephore."

In the most general sense telpher lines include such lines as were first proposed by my colleagues, Messrs. Ayrton and Perry. The word would also describe lines such as I have seen proposed in the newspapers for the conveyance of small parcels at extremely rapid rates. But to-night I shall confine myself entirely to the one specific form in which the telpher line first presented itself to my mind, and which it has fallen to my lot to develop. In this form telpher lines are adapted for the conveyance of minerals and other goods at a slow pace and at a cheap rate.

The problem which occurred to me was this: Was it not really possible to send vehicles, by means of electricity, along a single suspended wire or rod—in fact, to telegraph goods and passengers instead of messages? The idea is familiar as a joke, but on consideration it appeared that there must be good grounds for supposing that the idea was both practicable and useful. I am now able to show you the realisation of that idea, and the result of experiments on a large and practical scale has, I think, justified the arguments which induced me to devote much time and labour to telpherage.

[Here the model was shown in action. This model consisted of two concentric octagons of wire, the length of each outer span being 5ft. On each octagon there was a single locomotive and train, equal in length to that of the span. These trains ran well and steadily in opposite directions round the lines.]

These arguments may be stated as follows:—

We could not with steam employ a vast number of little one-horse engines to pull along a number of small trains or single waggons. There would be waste both in the production of power and great cost in the wages of the men employed at each engine. But an electric current of, let us say, 50 horse-power will, as it circulates through a conductor of moderate size, drive thirty small engines each of one horse-power, which require practically no supervision, and which can be made nearly as economical in their action as a single electro-motor of 30 horse-power could be.

But if the power can be distributed economically along a line, say ten miles in length, this allows us to employ thirty small trains, corresponding each to a waggon pulled by one horse, instead of a single train such as might require 30 horse-power. If we further distribute the weight by making each train of considerable length, we are able to employ an extremely light form of road, such as a suspended rope or rod of, say, ¾in. diameter. At a later period in the lecture I will show the amount of traffic which such a rod can practically convey. Meanwhile, I simply draw your attention to the general principles of the subdivision of power and the subdivision of weights. In distributing the power by means of electricity it was clear that considerable waste must be incurred, but the amount of that waste is easily calculated, and is by no means prohibitory. Moreover, the power, being obtained from stationary engines, or in certain cases from falls of water, could be produced at a cheap rate in comparison with that obtained from locomotives or traction engines.

When I examined the various forms of possible road by which the distributed power and distributed load could be conveyed it seemed to me that the single suspended rope or rod offered great advantages. The smallest railway involved embankments, cuttings, and bridges, fencing, and the purchase of land. A single stiff rail, with numerous supports, from which the train might hang, seemed better, and may, in some cases, be employed; but the supports would require to be numerous—say, one post every 10 or 15 feet—and even with these spans the girder required to carry vehicles weighing 2cwt. each would be costly. With a single suspended rod or rope we may have supports 60 or 70 feet apart. A ¾-inch rod, thus supported, will carry five vehicles, each bearing 2cwt., without excessive strain—no purchase of land is necessary, no bridges, earthworks, or fencing. The line could be removed from the ground so far that it would not be meddled with either by men or animals.

A single wheel-path gives the minimum of friction, and the rolling stock would be much more easily managed than if we attempted to let vehicles run on double swinging ropes. On all those grounds it seemed well worth while to devise means by which trains could be electrically and automatically driven along the single suspended rod.

Before proceeding further I had better state how far this idea has been realised. The Telpherage Company (Limited) was formed last year to test and carry out my patented inventions and those of Professors Ayrton and Perry for electric locomotion. On the estate of Mr. M. R. Pryor, of Weston, two telpher lines, on my plan, have been erected. One of these is a mere straight road, with spans of 60 feet, and various forms of rod and rope. The first full-sized train was run on this line with a locomotive which we call the bicycle-wheel locomotive. The line was found inconveniently large and high, and the experiments were continued on a line ⅝-inch diameter, of round steel rods, with 50 feet span. This line is continuous, that is to say it re-enters on itself. It is 700 feet long, and we have run a train of more than one ton at a speed of five miles per hour on this line with complete success. The insulation has given no trouble. It need hardly be said that we see our way to great improvements in details. Thus, we can make the road more uniform and stronger for its weight; we can lessen the quantity of material used, and greatly diminish the amount of skilled labour required in erection. We can improve the design of the posts. We can improve the trucks and locomotives so that they will go round sharper angles, and so forth, but the main object has been practically carried out. We have had trains, on a scale as large as I am prepared to recommend, running at the highest speed I have contemplated.

I trust it will be clear to you from this description that what I have contemplated and realised is not an electric railway destined to compete with steam railways in conveying goods and passengers at high speeds, neither is it a new form of communication destined for small parcels and high speeds; it is simply a cheap means of conveying heavy goods which, like coal or grain, can be carried in buckets or sacks each containing two or three hundred weight. The speed on a telpher line will be that of a cart, and the object we aim at is to cart goods at a cheaper rate and more conveniently than with horses.

I will assume that you all know that an electric motor is a machine which will run so as to exert power whenever an electric current is passed through it. You also know that a machine called a dynamo, driven by a steam-engine or other source of power, will produce an electric current which may be conveyed along a suspended and insulated rod, and used to drive an electric motor.

In describing the details of my system the first point to be explained is, how the current produced by the dynamo, and conveyed along a single line, is taken from that line and directed round the motor.

* Paper read before the Society of Arts, Wednesday, May 14, 1884.

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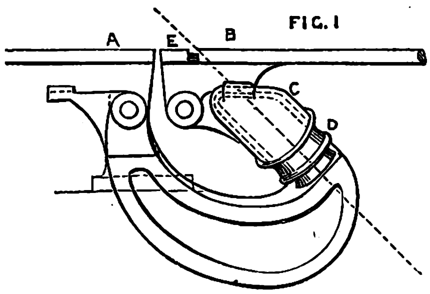
In endeavouring to realise this idea, the first thought which occurred to me was that of dividing the line into lengths, equal to the length of the train, so that using the train to bridge over a gap between two sections at different potentials, the current could be conveyed from the leading to the trailing wheels of the train, round the motor. This idea is employed in the model now shown; but, in the first form which suggested itself, the gaps between the sections were opened by a switch worked by the front of the train, and closed by a switch worked by the end of the train. The first model, which may have been seen by some present working in Fitzroy-street, was made on this plan. Trains driven in that way would all be coupled in series. The present model is differently arranged; there are no working parts or switches. Let the successive sides of the polygon be called the odd and even sides; the odd outer sides are connected with the even inner sides, and the even outer sides with the odd inner sides. We thus have two continuous conductors each going right round, but not joined to each other; these are connected to the two poles of a battery. So long as no train bridges a gap no current flows, but whenever the train bridges the gap, a current

FIG. 1



flows from the positive to the negative pole round the motor. This plan is called the cross-over system; all the trains are joined by it in parallel arc, and the current is reversed each time a train passes a gap. This reversal does not affect the working of the motor. This is the plan which has been carried out on a large scale at Weston. Its simplicity leads me to believe that it will be the plan most usually adopted, but several other methods of driving have been devised. A spark passes between the wheels and the line each time the current is stopped; but this spark occurs between large masses of metal, where it appears to be harmless; it has given no trouble whatever at Weston. Moreover, it has been found very easy to make connection between the line and the train. The ordinary truck wheels answer admirably, so that no complicated brushes are required. There are some absolute advantages in the interruptions occurring at regular intervals, but the discussion of these would lead me too far for my present purpose.

Only one of the two continuous conductors requires to be insulated; this results in alternate insulated and uninsulated sections all along each line. Fig. 1 shows a saddle, as we call it, with an insulated attachment at the one end and an uninsulated attachment at the other, as used for a short sample line which has just been

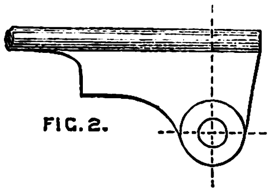


FIG. 2.

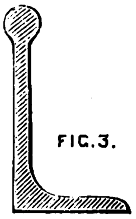
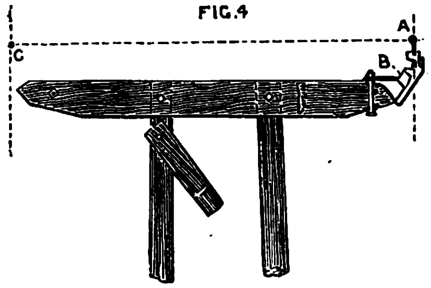


FIG. 3.

sent to Peru for the Nitrates Railway Company (Limited). The line itself is a three-quarter inch steel rod with forged ends, and the figure sufficiently shows the mode of attachment. The insulation is given by a vulcanite bell insulator. All the parts are designed to stand 2·2 tons strain; the vulcanite is secured between two layers of Siemens cement. The experiments at Weston have shown that vulcanite answers perfectly, but the material is rather expensive. I have here a smaller porcelain insulator, which has been subjected to 2·2 tons strain. I believe porcelain will answer well in all respects, but it has not yet been subjected to the test of actual traffic day by day. At Weston the vulcanite was used between layers of Portland cement, the only objection to which is that it takes some time to set. The simple steel rod has been found preferable in all ways to rope. We find that there is less friction and less jar with the rod, and ample flexibility; it is also much easier to secure. Moreover, a solid rod with welded ends can be made so that the ends, where supported, are, to some extent, undercut, and this allows much greater freedom of rolling than would be compatible with the horizontal gripping wheels, especially when gripping wheels are used which, like those in the model, actually hold on to the line so as to resist being lifted.

Fig. 4 shows the posts and crossheads supporting the line. In the one-inch example this design was fully carried out, and the posts stood the cross strain due to the overhanging load perfectly. In the five-eighth line an attempt was made to cheapen the construction, but the posts in wet weather work at the foundations. It is well that we are put on our guard against this danger. In the

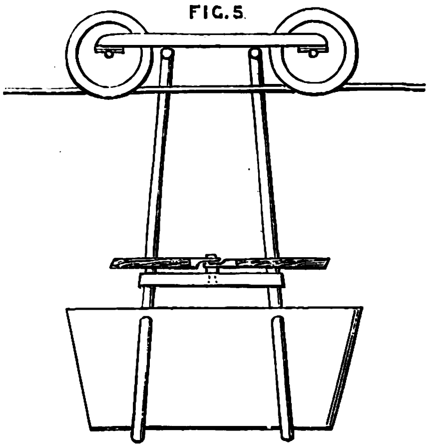
FIG. 4



first design a sort of rocking saddle was employed, to allow the strain to be transmitted from one span to the next, but the flexibility of the posts provides amply for this object.

Abutment posts are required at intervals, and these can be made use of to provide compensation for changes of temperature, and to limit the stress on the rods. In straight lines I reckon about four abutment posts per mile.

FIG. 5.



In the short South American line curves of 45deg. at the posts will be employed, as shown in the model. At the stations, where goods are to be handled, rigid supports will be more conveniently employed. A bulb angle-iron like that shown in Fig. 3, supported every ten feet, answers well at Weston, and a siding, leading the trucks off this line, has been satisfactorily carried out. The siding leads back to the line at a point between two flexible spans. In fine, it may be said to-night that the problem of the continuous

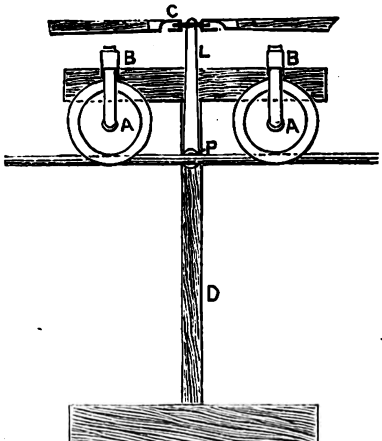


Fig. 6.

line, whether straight, curved, rigid, or flexible, has been completely solved. Drawings and specifications can be put, without further delay or experiment, into the hands of contractors.

Trucks used on ordinary rope lines are designed to be pulled by ropes on a road which is necessarily straight. When trucks of this description, with wheels 8in. diameter and 22in. wheel-base (Fig. 5)

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were tried at Weston, arranged in trains, some new difficulties presented themselves. Any sudden check to the motion was followed by a rearing action, throwing the truck off the line; similar results followed the application of any sudden pull. Moreover, trucks with two rollers on a rigid frame, even with so great a wheel-base as 22in., require curves of considerable radius if we are to avoid serious binding at the flanges. Notwithstanding these difficulties, the trains at Weston with a little care run well and lightly, but the trucks which have gone to South America are on the plan adopted in the model, and run much more safely and turn much sharper curves. They have two peculiarities—first, each wheel 7in. diameter (Fig. 6) is pivoted on an axis, B, vertically over the centre of the wheels, A; this allows the truck to run with the freedom of a bicycle round curves; secondly, the weight carried is hung on a swinging arm, D, pivoted to the frame at a point, P, on a level with the line. The result is that any force applied in a plane containing the line acts as if applied at the line itself, and will neither lift the wheels in front nor behind. In the model the coupling, as you see, is attached to the top of the swinging arm, where the coupling rods are well out of the way. The swinging arm, moreover, relieves the locomotive from all jerk at stopping or starting.

(TO BE CONTINUED.)

LEGAL.

Wandsworth District Board of Works v. the Postmaster-General.

On Tuesday, Sir F. Peel, in delivering judgment, reviewed the facts of this case, and in the course of the judgment he stated that the Commissioners had gone over the ground in order to inspect the places in Wandsworth (Old), Battersea, Clapham, and Tooting, where lines of wire, in circuits extending from three miles and a-quarter to eight and a-third miles, were proposed to be erected overhead. The circuits are primarily required for fire brigade and police purposes, and the circuits proposed to be made would consist of 16¾ miles overhead, and three and a-half miles underground. The underground laying was limited, inasmuch as the cost was £350 a mile, as against about £8 a mile for overhead wire, and if all the wires were to be laid underground the service could not be carried out. The underground laying was generally limited to places where there were more than five wires to be carried; and the Post Office engineers gave cogent objections against the general adoption of a mixed service of overhead and underground wires. The appeal was heard before the Commissioners under the Telegraph Act of 1878, which made them the arbitrators where the parties could not agree to the terms of a stipendiary magistrate or County Court Judge. The Commissioners examined the objections of the District Board, and the views of the Post Office engineers in great detail. They pointed out that the estimates showed that the cost of an overhouse line was about one-third the cost of a line on poles if the poles were of wood, or one-seventh if the poles were of iron, while underground work, as compared with overground work, would be at least 30 times more expensive. There were sections of each proposed circuit, where, it seemed to the Commissioners, wires might be put overhead as safely as if the roads were quite in the country, and under these circumstances, and taking the cost into consideration, the Commissioners could not agree with the District Board that the underground system ought to be made compulsory throughout the Wandsworth District. On the other hand, the Commissioners thought that overhead wires ought not to be put up except upon conditions which would give assurance of safety, and the judgment therefore added to the conditions laid down by Mr. Paget. The routes were marked out in detail, and the Commissioners laid down that the distance between the points of support on either side of a public road or street should not exceed 100 yards. Costs were asked for on behalf of the Post Office, but the Commissioners declined to make any order in respect to costs.

United Telephone Company v. Hebden.

In the High Court of Justice a few days since, before Mr. Justice Pearson, Mr. Cozens Hardy, Q.C., and Mr. Moulton moved, on behalf of the plaintiffs, for an order to commit the defendant to prison for disobeying an injunction restraining the infringement of the plaintiffs' patent by selling telephones in imitation of Bell's telephones. Evidence was produced in support of the application.—Mr. Renshaw, for the defendant, endeavoured to show that there had been no conduct on his part which would warrant his committal.—Mr. Justice Pearson said it appeared that the order for an injunction restraining the defendant from infringing the plaintiffs' patent was made by Mr. Justice Fry in December, 1882, and in February, 1883, that learned judge made an order for the committal of the defendant to prison for disobeying the order. An application was made on the 10th of March for his release, but Mr. Justice Fry refused the application. Subsequently, however, an order was made for his release. There was no doubt whatever, in his lordship's opinion, that the defendant had now committed a gross contempt of court in again disobeying the order restraining him from infringing the patent. The evidence was quite sufficient to prove that the defendant had been purchasing instruments similar to Bell's patent telephones, which had been manufactured at Rotterdam by an American company, and these instruments had been sold by the defendant in this country. Under these circumstances he should make an order for the committal of the defendant to Holloway Prison.

London Platino-Brazilian Telegraph Company (Limited).

The sixth ordinary general meeting of shareholders of this Company was held at the offices, No. 66, Old Broad-street, on the 22nd inst., under the presidency of Mr. Pender, M.P.

The SECRETARY (Mr. William Payton) read the notice convening the meeting and the minutes of the last ordinary and extraordinary general meetings, which were confirmed. The report of the directors was taken as read.

The CHAIRMAN: Gentlemen, before asking you to approve the report I beg to make one or two remarks. As you are aware, the gentlemen who are sitting at this Board some very few years ago rescued this Company from what I may call a total wreck, and since that time up to the present we have been paying 2¾ per cent. I may say that that 2¾ per cent. was paid upon a cost which probably, if the business had been carried out in a business-like way in the first instance, would not have been half the amount of the capital expended. However, that is a thing of the past, and a matter with which your Board had nothing to do. We came in in the interests of the shareholders—of the large shareholders, and some of the small shareholders—to rescue a concern which, as I have said, was drifting entirely upon the rocks. We are not managers of the Western and Brazilian cables—we have nothing to do with that company's cables; and on the good or bad management, or on the success, of the Western and Brazilian Company depends our dividend. Neither are the Western and Brazilian Company dependent on themselves, because their dividend is more or less earned from the success of the Brazilian Submarine Company. Well, the reason we are paying a smaller dividend this year, or one of the reasons, is that the Brazilian Submarine cable was interrupted for two months, and the result has been that the proportion we receive has been reduced, owing to that interruption, to £12,638, or a decrease, as compared with 1882, of, in round figures, £3,000, or just about ¾ per cent. dividend on our capital. This explains the reason why we are paying a smaller dividend to-day than we did this time last year, and it is a matter over which we have no possible control. The bright feature, however, in the case is that the Brazilian Submarine Company are duplicating their cables, and I have found from my experience in connection with submarine cables that unless your system is duplicated you can never trust to what I call a steady and continuous income. An interruption of two months is not merely the loss which is sustained by that interruption, but the influence it has in throwing back the spirit of telegraphy, which is very considerable. Telegraphy is now more or less conducted in the interests of commerce. They use it to a very large extent, and when men get accustomed to it and a break occurs it throws them back on their old ways of dealing with business, and that retrogression has to be made up again. I merely make these remarks because there are gentlemen present who have not always the opportunity of watching as closely as I do the effects of breakages of submarine cables. As, however, I said just now, the Brazilian Company are duplicating their system, and we may look to that fact for a more steady income in the future. The next point to which I wish to draw your attention is the Government debt. It appears as £7,360, and it is the debt due to us by the Uruguayan Government. We are trying to obtain that amount, and we are hopeful that before this year is out we shall obtain a settlement. The last information we have on this subject is as follows:—"Finance Minister to-day interviewed. Chambers have not yet sanctioned law proposed by Government to settle our old credit receiving unified debt at par without interest accumulated, but Minister expects will be sanctioned before end present year." Therefore, as you see, we are carrying on these negotiations, and I am hopeful that they will be carried on with success. With respect to the competition we meet with from the Brazilian Government, I have always stated, and I repeat it now, that I do not think the Brazilian Government have kept faith with those who have laid the submarine telegraph system. The Emperor himself told me that if we carried out the system to the Brazils we should have every possible encouragement on the part of the Government—that they could give us no subsidy, but that they would give us fair play and virtually a monopoly of the system. Instead of that they have started land lines to compete with the submarine system, and the result has been to lower the tariffs very considerably. The submarine lines are now obliged to compete with the Government, and the Government with a long purse behind them are competing at a loss, doing no good except to those who use the telegraphs, and inflicting considerable harm on the companies. I believe that the Western and Brazilian Company are keeping that matter constantly before the Brazilian Government, and I hope that the day will come very soon when they will be shamed into doing what is right. The next point is the question of the Six per Cent. debentures. Last time we were here we discussed that question, and after a good deal of consultation endeavoured to do the best we could for the Company. We succeeded in issuing our debentures at 6 per cent. instead of 7 per cent. I think the price we issued them at was a fair one as between those who received them and ourselves. We are, I think, entitled to the confidence of the public. I think these 6 per cent. Debentures are a very good investment indeed, and I am hopeful that they will be proved to be so by those who have obtained them, placing them in such a way as will be profitable to them and those who invest in them. As stated in the report, a difference has arisen between the Western and Brazilian Company and this Company. You are all aware that we receive from the Western and Brazilian Company a proportion of the gross revenue of that Company, and the difference of opinion which has arisen is as to whether the income does not admit of being looked at from two points of view. They have taken their view and we have taken ours, and they differ; but there are men of business at their Board, and I hope there are men of business at our Board,

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and I trust that we shall be able to settle this point on a fair basis. I can assure you of one thing as to this matter—namely, that knowing our position to be a strong one, we are not likely to make any concession which would be injurious to your interests, and your interests will be our first consideration in the settlement of this question. I do not think I need go further into the details of the question, and I think I have now exhausted all the points that I wished to bring before you. With these remarks, therefore, I will now move "That the report and accounts for the year ending 31st March, 1884, submitted to this meeting be and they are hereby received and adopted, and that a dividend of 2s. per share be declared, payable this day, free of income-tax."

Mr. JOHN HOLLOCOMBE seconded the motion.

Mr. ROBINSON KENDAL: Have the debentures been issued for any number of years?

The CHAIRMAN: Yes, for twenty years.

Mr. A. BAKER stated that at the last meeting he rather criticised the conduct of the Board in the placing of the debentures, but looking at the report, he thought that the amount charged for the issue was exceedingly small. In view of what he might have said at the last meeting, he felt very much pleasure now in saying that he thought the debentures had been issued as cheaply as possible. With regard to the difference with the Western and Brazilian Company, it seemed to him that it would be a great pity if they were obliged to go to law, and he should imagine that a settlement might be arrived at by a friendly arbitration between some of the members of the two Boards.

The CHAIRMAN: I think Mr. Baker takes just the business view of it that I took. As I said, there are business men on the Western and Brazilian Board, and on this Board, and though I will not say it would be discreditable, it would not be complimentary to us if we do not settle this matter ourselves. There are times, however, when the lawyers must be called in, but we will not do so unless we are compelled. We are, however, determined to protect your interests, and if our judgment is right we shall stand by our judgment.—He then put the motion in the usual manner, and declared it carried unanimously. Continuing, he moved the re-election as a director of Mr. Hollocombe. He said: Mr. Hollocombe's knowledge of Brazilian affairs has been most valuable to the directors, and I can assure you as chairman of this Company that I always feel that it is desirable to have about us some one who has special knowledge of the affairs and interests we have to deal with.

Mr. FRANCIS PAVY seconded the resolution, which was carried unanimously.

On the motion of Mr. W. FORD, seconded by Mr. KENDAL, the auditors, Messrs. Deloitte, Dever, Griffiths, and Co., were next reappointed.

Mr. KENDAL then moved a vote of thanks to the chairman and directors for their management of the affairs of the Company during the past year. He thought they had carried out the issue of the debentures very successfully, and in a manner highly advantageous to the Company. He regarded the charge of issue as very small indeed.

Mr. BAKER seconded the motion, which was carried unanimously.

The CHAIRMAN: I can assure you on the part of my colleagues and myself that we feel gratified by this expression of your opinion. We had a discussion at the last meeting on the subject of the issue of the debentures, and I think I then assured you that the interests of the Company would be safely conserved, and that we should be able to stand before you to-day and state that we had dealt with this transaction in a fair and business-like way. We have now your approval for having carried out this matter properly, and you can well understand that we are satisfied because you are satisfied. We believe that the business is fair as between man and man, and I have only to say that, looking at what is behind us, I do not know that there is any better debenture in the market than these. Six per cent. is not so easily got in these days. At the same time it has been beneficial to us, as we have reduced the rate by 1 per cent., and have thus established our credit on a firmer basis. I do not say there is a great prospect of obtaining a very large dividend from this concern, but now that the interest is reduced I think we can show that on the market price of the shares it is a very fair dividend. This concern, as I have said, cost more than double what it ought to have cost in the first instance, and at the price of the day there is something like the value of the concern. We give at the price of the day something like 4 per cent., and I see no reason why there should not be a moderate increase on that. I beg to thank you, gentlemen.

The proceedings then terminated.

The West India and Panama Telegraph Company (Limited).

The fourteenth ordinary general meeting of the members of this Company was held at the City Terminus Hotel on the 21st inst., under the presidency of Mr. C. W. Earle.

The SECRETARY (Mr. R. T. Brown) read the advertisement convening the meeting and the minutes of the last meeting, and the report of the directors for the six months ending 31st December was taken as read. It stated that "the amount to credit of revenue is £45,218 5s. 1d., and the expenses have been £20,617 15s. 2d., leaving a balance of £24,600 9s. 11d., which, with the balance of £3,287 15s. 3d. brought from last account, makes an available total of £27,888 5s. 2d. Of this sum the directors have placed £15,000 to reserve, leaving an available balance of £12,888 5s. 2d., which it is proposed to deal with as follows:—Payment of 6s. per share on account of arrears of dividend on the first preference shares, £10,368 18s.; balance to current half year's account, £2,519 7s. 2d."

The CHAIRMAN: The report divides itself as usual with us into three headings—first, financial; second, engineering; and third, what I may call plomatic, which means our relations with the fifteen different colonial governments and three home governments; and a very heavy task it is. As far as the revenue goes there is some satisfaction in seeing a small increase in the traffic—an increase of £4,174. I do not know that there is any special reason to account for this. I suppose it is one of the incidences of the West India trade—the sugar trade. Perhaps it was better in that period, the last part of last half year, than it has been. With regard to the expenditure there is also a saving in comparison with the corresponding period of £6,693. To a small extent this is owing to reductions we have been able gradually to effect in the current expenditure, but the bulk of it refers to the expenses of the ships, and the saving there is to a great extent accidental, for the "Grappler," which came home to be repaired, was employed by us in taking out new cable. The expense of that freight goes to the credit of the "Grappler," and to the charge against the cable when it is used. Therefore the expenses of the "Grappler" have been *pro tanto* less than if she had been stationed in the West Indies, and the cost of the cable she expended on the San Juan-Jamaica cable, to which I shall allude presently, is charged to the reserve fund, being practically a renewal, and therefore a fair charge against the fund, which was established for the purpose of renewals as distinguished from repairs. The "Grappler" was overhauled and put into thorough repair for the sum of £886, which I think was a very moderate amount. For the smallness of the amount we are very much indebted to Mr. Holmes, who is a practical man with regard to shipping, having been the owner and commander of ships, and that gentleman passed a great many days, and I may say a great many nights, on board that ship, superintending everything that was done in the way of repairs at that time. While on the subject of the amount I may call attention to the reserve fund, which up to the 31st December last had been invested in good securities to the amount of £55,255. Since then we have put an additional £26,000 into like securities, but as it was done after the end of last year it does not appear in this report. It is, however, satisfactory to think that we made this investment before the late rise in that class of stocks consequent on the announcement of the Chancellor of the Exchequer's views as to consols, and there is a profit of £2,500 on the investments we have made on account of the reserve fund. As to the repairs of the San Juan cable I am sorry to say that they promise to be more expensive than we anticipated. Last time I had the pleasure of meeting the shareholders the ship was just about starting to conduct the operations on that cable. In the meantime, before she had arrived, we had repaired the end of the cable nearest to Porto Rico. We had used the "Duchess" in a leisure moment to look into the matter, and she had got 45 miles in that cable. The "Grappler" came and joined up at the end of the 45 miles, and laid about 125 miles to the westward. She then came to a break and joined up the cable there; and in going to the westward again she found the cable so decayed that it broke seven times before they got it to the top. That proves that that cable must be relaid. While she was engaged on this operation the Jamaica-Colon cable failed, and we had to send her there, and she has not been able to return to the San Juan cable. At this moment the two cables belonging to the International Company are broken, and we have chartered the "Grappler" to go to repair them. This will give us a little profit this half year, and compensate us to some extent for the falling off that has taken place in our traffic, owing to the depressed state of the West India trade. Sugar has never been known to be so low as at this moment, and the result is that our revenue from traffic this half year is about 15 per cent. in arrear of what it was in the corresponding half of 1883. On the other hand, I have the satisfaction of reporting that the Demerara cable is repaired. We now come to the questions of the subsidies, the West India Commissioners' report, and our relations with the Governments generally. The present position is pretty clearly laid before you in the report in paragraph 4. We have got the assent of all the colonies that were represented at the Telegraph Conference in Barbadoes in 1882 to give us an increase, with the exception of Barbadoes. Barbadoes stops the way. The Government of the Leeward Islands say that they will not pay us an extra subsidy unless the increase be universal, and Barbadoes says that nothing at present will induce them to give an increase. Why Barbadoes takes this line I cannot say. Barbadoes has always been particularly opposed to us, and as the service there is performed in exactly the same way as at the other stations, I cannot really account for the difference in the feeling and sentiment there towards the Company. I am afraid it is in connection with that serious obligation which is on us of the news bulletin. The press of the island are constantly writing against us with the view of getting more news. Their object is to get long cable telegrams for nothing. This would increase the sale of their papers, and their cue is to be writing down the Company for the insufficiency of the news forwarded. Sometimes their charges against us are grotesque. In December last, for instance, we were strongly condemned for not sending them the Queen's Speech! With regard to the report of the Royal Commissioners, I was in hopes that something more favourable towards us would have come from their investigations. You see what they have written about the islands of the West Indies (displaying Blue Books). All the preamble till they come to the conclusions is very decidedly favourable to us. In talking of Jamaica they say, "The subsidy to the West India and Panama Company we consider to be for the benefit of the island generally." One of the witnesses in Jamaica said he was against subsidies, but he stated that it would be unwise to give up the subsidy to this Company. In St. Lucia they say "the expenditure on telegraphic communication is of great importance to the commercial interests of this island." One of the witnesses, a Mr. Hughes, said, "I do not think this

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expenditure (meaning our subsidy) can be safely dispensed with, and though the public generally may not use the system (and they do not), it is of great convenience." But then what is the outcome of all this favourable mention of the telegraph to the West Indies? I will read the summary of the commissioners. They say:—"The general commercial progress of these islands is dependent to a very great degree on trustworthy and continuous telegraphic communication, which is daily becoming more and more indispensable to the administration, commerce, industries, and indeed security, whether in the event of riot or of war, of our West Indian colonies. At present this communication among the various West Indian islands is provided by the cables of the West India and Panama Telegraph Company (see map No. 3). There have been many complaints of too frequent interruptions of communication, which, we were informed, had prevented merchants and others making such use of the telegraph as they would otherwise have done; but by the repair of old cables and the laying of new we are informed this system has now been placed in a satisfactory condition. But this system is connected with America, and so with Europe, by lines that run across Cuba to the United States, on which the charges for transit of messages are heavy, nor is there at present any alternative route in case of breakdown or war. We are of opinion that the West Indian telegraph system shonld be connected as soon as possible with North America, as well as with Europe, by a direct cable to Halifax *viâ* Bermuda, and that on the laying of this cable the West Indian colonies might, if necessary, well increase their subsidies, while other subsidies could be added from Bermuda and from Nova Scotia. At the same time, in order to secure the prompt laying of the cable, we are of opinion that both the Imperial and the Colonial Governments would do well to guarantee interest to a moderate amount on the capital required for the new cable for a certain term of years. Were this accomplished a profitable reduction in the tariff might well follow; communication would be absolutely reliable, and with these reforms we think the telegraphic companies would find the business amply remunerative; but we are of opinion that if such reductions in the tariff are contemplated, there should be no longer a demand for the supply of bulletins of news daily, and free of charge, by the Company, as is now the case. This demand trenches greatly on the legitimate income of the Company, and although by this means steamer companies and newspaper proprietors are relieved of certain expenses, we fail to see why the colonists in general, and this particular telegraph company should be saddled with the cost. We are not aware that such conditions are imposed elsewhere. The Company, it appears, is put to considerable expense to obtain bulletins of news for the English as well as the foreign islands; but as the same news is telegraphed to all, the French complain at the excess of English news, and the English at the excess of French news. We are of opinion that it would be far preferable in any new arrangements to omit any conditions as to the supply of gratuitous news. We would add that it would be greatly to the interest of the Canadian Dominion to secure such direct telegraphic communication, as it would assist to open up the natural trade between Canada and the West Indies, which already grows fast in the exchange of salt fish and flour for raw sugar and tropical products." You will observe upon this that their suggestion of any increase, any assistance, any relief to the Company is made dependent on our constructing, or some one constructing, 2,000 miles of cable in the deepest water in the world, between St. Thomas and Halifax, Nova Scotia, to carry the insignificant traffic of the West Indies, and on the reduction of the tariff on our own lines. It is a recommendation which means, "If you cut your own throat we will see if we can do anything to help you." As to reducing our tariff, if we did that we should be in a worse position than we are now. Every reduction of tariff that is made shows that it does not raise the traffic of the company doing it. As to this direct line giving us any increase of traffic, I believe it would be futile to expect such a thing. If you could telegraph almost for nothing between our system and Halifax I do not believe the intercolonial traffic over our lines would increase to any appreciable extent. We shall prepare a reply to Lord Derby on this report of the commissioners, but I must repeat the regret we have expressed in our report that, when every little petty question of roads, of subsidies for the killing of rats, and for the supply of ice to these colonies was gone into and evidence taken upon it, this important enterprise had not the opportunity of stating its views to the commissioners. He concluded by moving the adoption of the report and accounts, and the payment of 6s. per share on account of arrears of dividend on the first preference shares.

Mr. Henry Weaver seconded the motion.

Mr. Griffith thought the shareholders were very much indebted to the chairman and directors. Their position was certainly not altogether what could be desired, but it was satisfactory to find that some of the West India colonies had a sense of honour, and that there was only one of them, Barbadoes, which resolutely persisted in doing what was despicable and contemptible. He thought it was incumbent on them to try and move public opinion on this question. Those who were members of the Royal Colonial Institute might raise the question there, and others who had connections with the West India colonies might also similarly use their influence in proclaiming the conduct of Barbadoes. By that means the colony might be induced to follow the example of the other colonies. He thought, however, that it was a much more serious matter to find that a report had been issued by the Government, which had, he maintained, altogether ignored the principles of justice. In our courts of justice and before Parliamentary committees of inquiry it was not usual to interfere with the rights of parties without hearing the other side of the question. The Company had not been heard on the questions dealt with concerning them by the Royal Commissioners on the West India Islands, and it was not right that they should be saddled with the additional obligations referred to. There was a kind of honourable understanding between the Colonies and the Company that assistance should be rendered to the Company in connection with the working of the cables; it was quite clear that unless the Government of these colonies kept to this honourable engagement, or semi-engagement, to assist them, the Company was likely to prove a failure, and those who had invested in it would in that case get no return. The idea of imposing on the Company the new obligations referred to was preposterous; and as a matter of expediency the proposal seemed to him an outrage on common sense, as well as an outrage on common justice. The proprietors ought to support the Board in the protest they were prepared to make, and unanimously help them in resisting a project which was, he contended, injurious, dishonourable, and altogether prejudicial to the best interests of the Company.

Mr. Veares believed that the directors thought they were doing right, but in his opinion the shareholders must look nearer home for some remedy to the existing state of things. Their hearts sank on reading the reports which the directors periodically presented to them; and with regard to the present report a pessimist might find a pasture ground in it, while an optimist could not discover a single gleam of hope. All the interests of the ordinary shareholders were practically mortgaged to the first preference shareholders. He thought a portion of the reserve fund might be employed in paying off the debentures, by which the interest on that head would be saved.

A Shareholder asked whether Barbadoes could not be cut off from the telegraphic conveniences given to them by the Company.

The Chairman: I am afraid if we were to do that we should find all the other colonies withdraw their subsidies. I do not know that there are any questions which I have to answer. As to Mr. Veares's suggestion to pay off the debentures with the reserve fund, I am afraid that would not be a safe course. The reserve fund is to meet any renewals or requirements with regard to the cables that may be necessary to keep the thing going, and if we applied that fund to the debentures we might be in a difficulty if we wanted £50,000 or £60,000. He then put the resolution, which was carried unanimously.

The retiring directors and auditor having been re-elected,

Mr. Griffith moved a cordial vote of thanks to the chairman and directors. The Company had the advantage of having the services of men of experience and tried character, and but for that fact he believed their success would have been still less. He had said that they had men of tried character at the Board, and as to that he had had the pleasure of listening to the masterly vindication by the Lord Chief Justice of England of Sir James Anderson.

Mr. Robinson Kendal seconded the motion, believing the directors were thoroughly well entitled to the thanks of the shareholders.

The motion was carried unanimously.

The Chairman: On behalf of myself and colleagues I beg to express our sincere thanks for the vote which you have just passed. We shall always do the best we can for you. We are only sorry that our efforts are so little successful after so many years of constant attention and work. As Mr. Ford reminds me, we shall press our representations on the Colonial Office as to what is stated in this report of the Royal Commissioners.

The proceedings then terminated.

Maxim-Weston Electric Company (Limited).

An extraordinary general meeting of this Company was held on Friday, the 16th inst., at the Cannon-street Hotel, Mr. Hugh Watt in the chair.

The Secretary (Mr. J. B. Cox) having read the notice convening the meeting,

The Chairman said that in moving the first resolution he might briefly repeat what he stated at the last meeting with regard to their determination to reduce the capital by £100,000. The balance-sheet issued for this year by the present Board dealt with the expenditure for two years, and it amounted to £32,283 13s. 3d., which of course had been carried forward, and they proposed wiping it off. The same thing was proposed to be done with regard to parliamentary expenses. The loss on stock and on re-valuation of plant and machinery was put at £16,757, and that might have been taken at a lesser sum, because at the time he took care to have estimates from various pepole to see what they considered it worth in the trade, and they had put the loss down at something like £2,000 in excess of those estimates. The surrender of the lease and building at Bankside cost £2,256. They used every possible means, and went to an expense of £20 to get rid of that lease. They were advised that the best plan was to relinquish the lease; but they could not get a single farthing for the sum expended, which was £1,800 and £500 premium, so that the sum of £2,256 became a total loss. Then as to the reduction in the price of patents, the present Board, considering that the sum at which the patents appeared in their books was in excess of their actual value, were desirous of bringing it down to what was their real value. As he explained at the last meeting the patents had been greatly enhanced in value by recent improvements. With regard to the incandescent lamp, they were out of the market with their own; though at the time it was the best. It required, however, an amount of current much in excess of more recent incandescent lamps, notably the Swan; consequently, when it became a question of installing so many lamps for a lump sum they were quite out of it, because their dynamos would not run the same number of lamps as other companies'. Well, they had got a new lamp—and on that he spoke very fully at the last meeting—that took less than half the current of the old lamp of 16 candle-power, but retained all the features of the old lamp, namely, purity and durability, durability being the main feature. The other lamps were usually described as high tension, inasmuch as they required 100 volts to each lamp. Of course that materially affected the durability, and he

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might say that recently they had had many applications for their lamps to supplant those of other makers. As a rule the policy of the Board had been not to sell lamps, because the profit was infinitesimally small; the main profit was on the dynamos, and one reason why the profits of this Company during this present year had been satisfactory was that the new lamps enabled a dynamo capable of running 80 lamps to run 200. The old price of the dynamos he had been able to maintain, and in some cases to get more, but perhaps it was not judicious to go into details. Last year they sold an enormous number of carbons, of which they kept a large stock, and found it a very important item indeed. In one contract for carbons alone they cleared between £400 and £500 in five or six months, and he had every reason to believe that the Government who took those carbons would not only give them orders for further carbons but for a very large quantity of stock in the ensuing year. The carbons had been adopted in one of the departments of that Government, and arrangements were pending with them to take very extended plant indeed. He believed the shareholders would agree with him that it was undesirable to saddle the Company with such a large sum for patents as £100,000; they had reduced it to £70,000. Their new dynamo had been characterised by engineers and electricians as the best in the market. The reduction on shares received for licences and concessions was £17,171. Those were taken at par value in the last balance-sheet; but they were aware of the condition of electric lighting companies, and they were also aware that some of those shares had no quotation, so that in the event of their placing them on the market they would have to accept what was offered for them. They did not intend to place them on the market, but at the same time they had reduced them to 2s. 6d. in the pound all round. He thought that they were worth that, and that they might realise a little more. He thought they were entitled to take them at that, and the sum to be deducted was therefore £17,000. With regard to the loss on the new shares issued, the shareholders gave their consent to the shares being issued at 5s. They issued them, however, in the balance-sheet that had to be dealt with as £1 fully paid shares. The present Board, including Mr. Gray and his own friends, had subscribed nearly all those shares. He had no wish to take them, but the shareholders did not come forward, and they wanted capital. As the shareholders did not think proper to respond, the directors took those shares and had paid the debts of the Company and had gone on since. With regard to the profits, those profits had been derived from the sales of dynamos, lamps, carbons, new armatures, and so forth—out and out sales. They had fitted up about a score of complete installations, and he had now an order to fit up some large ironworks, and he had three or four promises. He always thought it better to go personally and arrange these matters. They had been lighting several places with great satisfaction, and he thought that during the year they would be able to show very good results. He honestly believed that they would be in a position in the current year to pay a dividend, and the shareholders might depend upon its not being paid out of stock. He moved "That the capital of the Company be reduced by £100,000 by cancelling paid-up capital which has been lost, or is unrepresented by available assets, to the extent of 10s. per share upon each of the 200,000 shares which have been issued and are now outstanding."

Colonel GILBY seconded the resolution, which was carried.

The CHAIRMAN said that the second resolution followed as a natural corollary on the first resolution, unless they made two classes of shares, for which there was no object. He moved "That the capital of the Company be further reduced by £150,000 by reducing the nominal amount of all the shares in the Company's capital from £1 to 10s. each, thereby leaving the nominal capital of the Company £250,000, divided into 500,000 shares of 10s. each."

The motion was seconded by Mr. Brown, and carried.

The CHAIRMAN said that at a meeting just held of the Lancashire Company the re-absorption of that company by the Maxim-Weston had been unanimously agreed to, and he thought that that measure would be in the interest of both concerns. There was no doubt that if all the shareholders in that company had paid up their calls, that would have been one of the most thriving companies in Britain—he might say in Europe. Unfortunately they did not pay. As it was the Lancashire Company was in a state of insolvency. Of course he did not look to the assets of that concern, but they took over a business that had been developed. There had been the foundation laid of a large business. They had lit the streets in Liverpool in a way that no company in Europe could do. Those streets had been lighted satisfactorily for two or three months without a single hitch, and the lights were beautiful. They had also opened up a business in private channels. One of the late directors had had his house lit up with 200 lights. That had been done on a sumptuous scale, and was admitted to be the most successful installation in the country. With regard to Manchester the installation there was simply beautiful, and there they had lit up some magnificent warehouses. He proposed the third resolution:—"That no further issue of shares in the Company beyond 50,000, making with the 200,000 shares already issued 250,000 shares, be made without the sanction of a resolution of the shareholders passed at a general meeting of the Company, to be duly convened for the purpose."

Mr. SWABY seconded the resolution, which was put and carried.

The CHAIRMAN said that by the absorption of the Lancashire Company they would have an important district, which in any other hands would have been futile, because in the event of the liquidation of the Lancashire Company the concession must revert to this Company. They got the plant of that company, which would be useful; the machines might not be in perfect order, but that they could remedy. He had made overtures to the Corporation of Liverpool, with the view of lighting such parts as would prove remunerative. He had seen the town clerk, who expressed himself very favourably with respect to the lighting, and also the electrician and engineer; but there was always some difficulty and delay in dealing with corporations. With regard to Liverpool the main difficulty in dealing with the Corporation was the all-powerful interests of gas. They admitted that the lighting was being carried on at a saving as compared with gas, and that they gave more candle-power. The difficulty in pushing their business was owing to the discredit attaching to other companies, and the numerous failures of the great bulk of arc installations. He was going north with the view of entering into a contract for the lighting of a theatre, an hotel, and another large ironworks, so that he thought he might safely augur for this Company a very successful future.

Admiral INGLEFIELD asked whether they made the carbons.

The CHAIRMAN replied in the negative, and said that they bought them and sold them at a large profit. With regard to the lighting of the "Gallia," he ventured to say that no steamer had ever been lit in a more satisfactory manner, and he had no doubt that other companies would adopt the light when the ship came back.

A vote of thanks to the chairman and directors then terminated the proceedings.

The Lancashire Maxim-Weston Electric Company (Limited).

An extraordinary general meeting of this Company was held on Friday, the 16th inst., at the Cannon-street Hotel, Mr. Wentworth in the chair.

Mr. REEVES (the solicitor) said that the liquidators had found it necessary to call the shareholders together for the purpose of placing before them a proposal which had been made to them by the Maxim-Weston Company for the purchase of all the assets of this Company. The proposal was one which the liquidators without the authority and sanction of the shareholders could not deal with or carry out. The Act of Parliament required that their authority and sanction should be obtained by means of a special resolution, and that made the present meeting necessary. In the opinion of the liquidators it was very desirable that this proposal should be accepted, and the arrangement carried through. As they were aware, the principal assets of this Company consisted of plant and machinery, which was useful only and could be used only for the purposes of electric lighting, and of the patents which were possessed by the Maxim-Weston Company. It was therefore very difficult, if not impossible, to find any person who would be willing to come forward and purchase at anything like a reasonable price such assets as those. The proposal which had been made by the Maxim-Weston Company was—that the Lancashire Maxim-Weston should sell and the Maxim-Weston Company should purchase all the assets of the Lancashire Maxim-Weston and all other the property and effects of the Lancashire Company of every kind and description whatsoever. The consideration of the purchase would be that the Maxim-Weston Company would pay all the debts and liabilities of the Lancashire Company, and would indemnify the Lancashire Company and the liquidators therefrom. The Maxim-Weston Company would give the shareholders of the Lancashire Maxim-Weston Company one share in the Maxim-Weston Company for every fully paid up share in the Lancashire Maxim-Weston; that was to say, the shareholders of the Lancashire Maxim-Weston would get share for share in the shares of the Maxim-Weston. That was the proposal, and it would be for them to consider whether in their opinion it was not very desirable that the liquidators should have power to carry it out.

The CHAIRMAN said that he could only add that he and his colleague had called the shareholders together after very carefully considering this matter, which was one of practical amalgamation with the parent company, and both Mr. Brown and he believed that that was the only course they could pursue. They had made overtures, unofficially certainly, to various people who might be likely to entertain the project of buying the assets of this Company without receiving any real response, and the only course they had open was to accept this offer, which he considered a very fair and liberal one on the part of the parent company. If that were not accepted they could only sell the plant for what it would fetch, and they knew what selling electric lighting plant would be. It would have to be done at a very great sacrifice, and he therefore very strongly recommended the shareholders to accept the proposals of the parent company, and he hoped they would do it unanimously, so that they might get to work as soon as possible under very favourable auspices.

Admiral INGLEFIELD said that, as a late director of this Company, he should like to make a few remarks. He would ask what had been done with reference to the claims they had on two gentlemen who were largely indebted to the Lancashire Company, because it was on the failure of their paying the calls on the shares allotted to them at their request that the Company found itself in the present position. At the last meeting the directors declared themselves, and were admitted by the Maxim-Weston, to be a flourishing concern, and if the calls he had alluded to had been paid the Company would now have been going on successfully. He asked what was the position of the Company in regard to the law suit with Messrs. Harding and Dadson.

A SHAREHOLDER asked if all the calls were got in what would be the condition of the balance-sheet—if it would show a debit or a credit balance? It was necessary that they should know that in order that they might know what they were handing over to the parent company. He also asked the liquidators if they had gone into the business of the parent company and satisfied themselves that the business was of a satisfactory nature, and that it was a thoroughly solvent concern that they were asking the shareholders of this Company to join. He presumed the liquidators had seen the working of the other company, and could assure the shareholders of the Lancashire Company that they were asked to transfer their business to a really sound and profitable concern.

The CHAIRMAN replied that the law suit was still progressing. He believed that some overtures had been made as to a compromise or settlement of those claims, but nothing definite had been arranged. They did

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not consider, as liquidators, they could precipitate or push those matters unduly, and if the present offer were accepted the whole of the responsibility in regard to this matter would be thrown on to the parent company. As to the condition of the Lancashire Company, he must differ from the view of Admiral Inglefield. They might have pottered on, but they could not have carried on successfully. They might have gone on for two or three months provided they had got the calls in, but they had been suffering from the very first from an utter inadequacy of capital. They had only had about £8,000 of paid-up capital to undertake all the work that they had to do, and they could not have gone on on the limited scale they had been doing; and experience had proved that they could not make the thing pay without a considerable increase of capital, and with the discredit thrown on electric lighting generally it was hardly likely the public would put any fresh capital into the concern. He should have been very sorry to have asked any of his friends to have done so. The Lancashire Company, if rentals were going to be the thing of the day, was in a position second to none for carrying on a good business, but his experience of the last eighteen months was that rentals would not pay, and the sooner rentals were done away with the better. He did not mean to say that there might not be isolated cases where they might make a good contract and it might pay. They had one in Manchester, but so far as Liverpool was concerned it was his opinion, and it was the opinion of the directors of the parent company, that if they took over this business they would have to close the Liverpool business as a rental business. With respect to the real condition of the affairs of the parent company, of course he could not say that he knew any more than the general public who had the opportunity of looking at and inspecting their balance-sheet. His co-liquidator, however, was a director of the Maxim-Weston and might be able to answer the admiral's question. By special resolution they wiped off half their capital, and the 10,000 shares that were paid to them for the promotion of this Company were going to be wiped out, and the shares that would be issued would be shares of 10s. fully paid.

Admiral INGLEFIELD said that at a previous meeting it was stated that their light was so excellent that it had virtually swept away all opposition. That was said at a meeting of the parent company, so that it appeared that that and this Company were the best electric lighting companies in England.

The CHAIRMAN: I believe that.

Admiral INGLEFIELD said, that that being so, they were tenacious, first of all with regard to the directors, who he thought deserved some little credit, and secondly because they were going to sell a very excellent concern of high repute, share for share, to the parent company, which had a very large capital, and which was doing no business that he knew of.

A SHAREHOLDER asked if the claim against Messrs. Dadson and Harding was of so shaky a nature that there was any reason that they should compromise it. They had been told that the shares had been honestly and properly subscribed.

Mr. REEVE, the solicitor, said that as regarded Mr. Dadson, as far as he could judge of the case, he thought that the Company must succeed. He did not make the remark as at all doubting Mr. Dadson's position, but supposing that Mr. Dadson were able to pay, he had no doubt that the Company would recover.

A SHAREHOLDER: How much?

Mr. REEVE: The balance that was due—he thought about £2,000. With regard to Mr. Harding the case raised two questions, and he thought upon one it was extremely doubtful whether the Company could succeed in recovering—that was upon the promissory letters. That might involve a great deal of litigation, and the result he considered extremely doubtful. The Company might, however, succeed in establishing some sort of claim of that branch of their case; but with regard to the first part of the claim, that was to say, on the shares which Mr. Harding took clearly as a shareholder, he thought there could be very little doubt of that being in favour of the Lancashire Company. The amount of that would be about £1,200, and he was told there was a counter claim of £600.

Admiral INGLEFIELD: It is a very questionable one.

Mr. REEVES was not in a position to say much about that; but as regarded the Company's claim, that would be limited to the £1,200, and that he thought they might depend upon recovering, subject, of course, to any counter claim.

Mr. CAMPBELL asked the number of shares that were subscribed.

Mr. HUGH WATT: The number was about 15,000.

Admiral INGLEFIELD: It was under 15,000, but Mr. Harding pressed the directors to allot, as the number he said was certain to be made up.

Mr. HUGH WATT said that the present position of the Lancashire Company was such that it could not go on. Only that day they asked the parent company for a cheque to pay their wages. He wished to do the best he could for the Lancashire Company, because he himself and many of his friends were shareholders in it.

Mr. CAMPBELL thought that some explanation should be given as to how the profit shown in the balance-sheet of the Maxim-Weston Company was arrived at. He had seen a good many balance-sheets, and knew that unless they went into details they were not worth the paper they were written on. It might be correct, but they should have some explanation as to how the £5,000 profit was arrived at.

Mr. HUGH WATT: On sales.

Mr. BROWN: On sales of stock. That question was asked at the general meeting, and it was thoroughly explained to the satisfaction of all the shareholders present.

Mr. CAMPBELL said he was not a shareholder of the Maxim-Weston Company.

Mr. BROWN: If you read the report and balance-sheet I think it will be quite satisfactory to you.

Mr. CAMPBELL: I have read the report and balance-sheet, and can make neither head nor tail of them. How is that £5,000 made up?

Mr. BROWN: Those are sales actually made of dynamos, lamps, carbons, and other stock, engines, and so on—all new plant, or nearly new plant—4,000 to 5,000 new lamps.

Admiral INGLEFIELD said that as they were asked to sell their business to another company they ought to know the position of that company.

Mr. CAMPBELL asked what was the cost of the different materials landed in this country, and what was the amount they were sold for? If they knew that they would be able to judge what was the profit.

The CHAIRMAN did not think that they had any right to go into matters connected with the parent company. They were recommending them to take shares in the parent company, and they did so because they believed it to be a sound concern. He thought that Mr. Brown could reassure the shareholders generally without going into matters of detail.

Mr. CAMPBELL did not think that an explanation without details could be satisfactory.

Admiral INGLEFIELD asked if the Maxim-Weston was equal to carrying on the concern?

Mr. CAMPBELL knew that some time ago the report of the parent company told of immense success, and their report was absolutely unjustifiable by the facts. That was the report of a year ago, and without knowing something of the details he was naturally suspicious whether the same thing was not the case now.

Mr. BROWN said that a year ago he was not a director of the parent company, but he was not surprised at the remark that had been made. When he joined the Board of the Maxim-Weston the company was in a most hopeless condition. They had not money to pay the wages and had to borrow.

Mr. HUGH WATT: Who was the chairman then?

ADMIRAL INGLEFIELD said that he was chairman, and without his knowledge a circular referring to the condition of the Company was issued to the shareholders and read at the third adjourned general meeting. It took him completely by surprise. They were making a loss of £230 a week; but at the time of the annual meeting, of which he was then the chairman, they had a profit of £200 a week, therefore they had been brought to a very flourishing condition.

Mr. CAMPBELL said the managing director then was the same as the managing director now, and he declared then that there were immense profits; and as the same kind of statement was made now, was it not fair that they should ask for details when they knew that the statements made last year were not in accordance with facts?

Mr. HUGH WATT said that the statements made were in accordance with facts. The statement was prepared by Mr. Reeve, the then accountant of the company, and showed that for a month or two previous there were profits, but those profits did not cover the deficit. There were large sums owing, and they went to carry on the Company, till the end of 1883. Those profits were absorbed in carrying on the City installation and other ventures that had been gone into by the gentlemen they saw present.

Admiral INGLEFIELD: That I own, but you had been managing director for some considerble time.

The CHAIRMAN pointed out that this was a meeting of the Lancashire Company, and that the affairs of the parent company ought not to be brought up.

Mr. BROWN also argued that it was irregular to go into such details at this meeting.

The CHAIRMAN said that if they were not satisfied with the proposal they should refuse to ratify it, but he should like to know what better course could be taken. They had been going on from hand to mouth for the last two or three months, and it was now a question of amalgamating or shutting up their place and selling their stock for the best price they could get for it.

Mr. CAMPBELL thought it would be better to sell the Company if they could only get a shilling in the pound, rather than hand it over to a concern from which they might get nothing.

Admiral INGLEFIELD would like it to be understood that he was not opposed to amalgamation, but he wanted it to be perfectly understood what they were doing, and that they were offering their business for a fair remuneration.

Mr. HUGH WATT thought he was justified in asking the chairman whether, in the event of their plant being sold, they could pay their debts, much less a shilling in the pound?

The CHAIRMAN replied that that would depend upon how the plant was sold; if they sold it as a going concern they could pay their creditors, but he questioned whether there would be much for the shareholders.

Mr. THOMPSON, in reply to a shareholder, said that at present there was not much going on in Liverpool except stagnation. He honestly and truly believed the Lancashire to be the only practical and legitimate Company in existence—the only Company able to demonstrate that electric lighting could be done, and if they had had the sums due paid by the shareholders they might have gone on.

The CHAIRMAN said that if they wanted to know the condition of the Maxim-Weston they could not do better than go to the Stock Exchange, and there they would find that the shares sold at 4s. to 5s. They could from that gauge the value of their shares in the Lancashire Company in the event of an amalgamation. The present value of the shares of this Company was *nil*.

Admiral INGLEFIELD thought he might say on behalf of the late chairman that he was quite in favour of the proposal, seeing that they could not go on without money, and they had a difficult law suit hanging over their heads which might be extended for a considerable length of time. In fact the proposal was the only alternative to liquidation.

On the motion of the CHAIRMAN, seconded by Admiral INGLEFIELD, a resolution was then passed, accepting the proposal made by the parent company.

A vote of thanks to the liquidators then terminated the proceedings.

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COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. MAY 21.		BUSINESS DONE WEEK ENDING MAY 21. Highest.	Lowest.
Anglo-American	31½,	32½	32¼	31¼
Do. Preferred	57½,	58½	58½	57
Do. Deferred	6½,	7½*	7½	6 11-16
Brazilian Submarine	10,	10¼	10 5-16	10 1-16
Cuba	9¾,	10¼	10	—
Do. Preference	16½,	17½	17¼	17
Direct Spanish	4½,	5	—	—
Do. Preference	14¼,	14¾	14⅝	14⅛
Direct United States Cable	9¾,	10	10	9¾
Eastern Telegraph	10⅞,	11⅛	11⅛	10 15-16
Do. 6 per Cent. Preference	13,	13½	13½	13¼
Do. 5 per Cent. Debentures, 1899	102,	106	—	—
Eastern Extension	11⅜,	11⅝	11 11-16	11 7-16
German Union	9¾,	10¼	9¾	—
Globe Telegraph and Trust	6⅜,	6⅝	6 9-16	6½
Do. Preference	12¼,	12½	12½	12⅜
Great Northern	13½,	13¾	13¾	13⅝
Indo-European	31,	32	31	—
Mediterranean Extension	1¼,	1¾	1½	—
Do. Preference	2,	4	—	—
Reuter's	8,	8½	—	—
Submarine	150,	160	157	154½
West India and Panama	⅞,	1⅛	—	—
Do. 1st Preference	7,	7½	7¼	—
Western Brazilian	5¼,	5½	5½	5 7-16
Western Union 7 per Cent. 1st Mortgage	121,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	106	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅛,	¼	⅛	—
Oriental	⅛,	⅜	—	—
United Telephone	7½,	8	8	7 11-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1⅛,	1¾	1 9-16	1⅛
Do. (fully paid)	2¾,	3¼	3	—
Hammond Light (£3 15s. paid)	½,	¾	⅝	½
Eastern Electric (£4 paid)	—	—	—	—
Swan	¾,	1	⅞	¾
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	33,	34	33⅝	33¼
India Rubber, Gutta Percha, and Telegraph Works	23½,	24½	23⅞	—

TO BE SOLD BY TENDER, in four lots, pursuant to an order of the Honourable Mr. Justice Pearson made in an action "Pedley v. Rogers and others," with the approbation of the judge, certain ENGINES, Machinery, Dynamos, and other Electrical Appliances and goods, situate at 57, Wellington-road, Barnsbury, in the county of Middlesex. Tenders are to be sent to Mr. Arthur Cooper, of 14, George-street, Mansion House, E.C., the Receiver in the said action, not later than JUNE 2, 1884, when they will be duly considered and be subject to the approval of the Judge at Chambers on Monday, June 16, at twelve. Catalogues and conditions of sale and forms of tender may be had of Messrs. West, King, Adams, and Co., 66, Cannon-street, E.C., Solicitors; of Messrs. Rogers and Chave, 3 and 4, Great Winchester-street-buildings, E.C., Solicitors; of Messrs. Pedley and Bartlett, of 23, Bush-lane, E.C., Solicitors; and of the Receiver.

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NOTES.

ANOTHER PAPER.—The *Electrical Era* has been started in Philadelphia, U.S.

ELECTRIC LIGHT IN THEATRES.—The Teatro Reggio at Turin is now lighted by the Edison system.

MADRAS.—A new post and telegraph office has been opened in Madras at a cost of six or seven lacs of rupees.

POLICE TELEGRAPHS IN BOSTON.—Boston (Mass.) is going to spend 250,000 dollars on fitting up a system of police telegraphs.

ELECTRIC LIGHTING IN LIVERPOOL.—The Maxim-Weston Company have intimated their intention of discontinuing their lights in Liverpool.

PROVISIONAL ORDER.—Electric Lighting Provisional Order Bill No. 2 was passed through committee in the House of Lords on Friday, 23rd inst.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending May 23, 1884, amounted to £2,840.

HONOURS FOR ELECTRICIANS.—Sir William Thomson and Professor Edward Frankland have been named as honorary members of the Vienna Academy of Sciences.

SPAIN.—Heavy gales occurring last week in the south of Spain are reported to have done great damage to the telegraph lines, Madrid being quite cut off from the south.

NEW CABLE.—It is probable, says a contemporary, that Port Blair will shortly be placed in telegraphic communication with Burmah by means of a sea cable to Diamond Island.

APPOINTMENT.—Mr. T. Arthur Highton, late assistant secretary of the Jablochkoff Electric Light and Power Company (Limited), has been appointed secretary to the Piccadilly Art Galleries Company.

TELEGRAPH AND TELEPHONE POLES IN BROOKLYN.—According to an official report there are 5,817 poles and 3,001 miles of wire used for telegraph and telephone purposes in the city of Brooklyn, New York.

SPANISH NATIONAL SUBMARINE TELEGRAPH COMPANY.—This company have removed their head-quarters from Teneriffe to Cadiz. It is stated that the company have arranged to lay a cable from the Canaries to Puerto Rico.

MEASURING INSTRUMENTS.—We shall hope shortly to publish the paper recently read by Professors Ayrton and Perry, before the Royal Society, on "A New Form of Spring for Electric and other Measuring Instruments."

SIXPENNY TELEGRAMS.—Owing to the pressure on our space we are compelled to postpone the publication of Colonel Webber's paper on telegraph tariffs. We have, however, dealt with the subject in our leading article this week.

ELECTRIC LIGHTING BY PRIMARY BATTERIES.—On Wednesday Mr. I. Probert read a paper on this subject before the Society of Arts, Mr. W. H. Preece, F.R.S., being in the chair. We shall hope to find space for this paper in an early issue.

ELECTRIC LIGHTING AT TURIN.—It is stated that the Town Council of Turin have concluded a contract with the representative of Messrs. Siemens for lighting the Place Carlo-Felice in that city with Siemens lamps. The contract is to extend over ten years.

FURNITURE EXHIBITION.—In our note under this heading in last week's issue, the name of the firm mentioned as having carried out the electric lighting work therein detailed should have been Gretton, Mynn, and Co., and not Gretton, Thynne, and Co., as printed.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending May 23, 1884, were £2,256, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited).

THE WEST INDIES.—The cable between Trinidad and Demerara is repaired, but the cable between Key West and Havana is still interrupted. During the interruption telegrams can be forwarded without delay, *viâ* Galveston, to places in the West Indies and British Guiana.

NOTICE OF REMOVAL.—We are informed that the following companies—viz., the South-Eastern Brush Electric Light and Power Company, the Provincial Brush Company, and the Consolidated Electric Company, have removed their offices from 110, Cannon-street, to 68A, Cow Cross-street, E.C.

THUNDERSTORM IN VIENNA.—A telegram from Vienna, dated Monday last, says:—A violent thunderstorm passed over Vienna yesterday afternoon, doing great damage in the suburban districts. A young peasant was killed in his farmyard, and several houses in the same village were set on fire, one old man being burnt to death before assistance could be given.

LIGHT HEMP CABLES.—We notice that Mr. H. S. Baker has taken out a patent for covering of cables with plaited hemp. It will be remembered that Captain Trott, at the Society of Telegraph Engineers, not long since spoke very favourably of light cables, and of the lasting properties of hemp in sea water. Mr. Baker claims to have produced the type of cable there described.

THE TELEPHONE IN NEW YORK.—The *Pall Mall Gazette* is of opinion that the Underground Telegraph Bill, which has passed both Houses of Legislature in New York and only awaits the approval of the Governor, is enough to crush the life out of any undertaking. The Bill requires all wires connected with telephones, telegraphs, or electric lighting to be put under ground before November of next year.

ELECTRIC LIGHTING AT GREENOCK.—The Greenock Police Board have resolved to make some experiments in electric lighting. They are going to set up a 25 horse-power turbine at Prospect Hill filters, which is to drive a dynamo capable of feeding 100 incandescent lamps of 20 candle-power. Mr. Mavor, electrical engineer, of Glasgow, has been called in to advise the Board in the matter. The experiments are to cost £1,435.

OIL WORKS STRUCK BY LIGHTNING.—Lloyd's agent at Philadelphia telegraphed on Saturday evening, the 24th inst., that the Atlantic Refinery had been struck by lightning. Forty thousand barrels of petroleum were on fire, and the fire was spreading. Twelve tanks were reported to have burst. The city gasworks were endangered. The British barque "Faith" and the Italian barque "Emilia M." were towed to a safe anchorage. The shipping had sustained no damage.

ELECTRIC LIGHT ON SHIPS.—H.M.S. "Dolphin," Commander S. E. Wilmot, was to leave Sheerness for Suakin this week as soon as her electric light fittings could be completed. It is not so long since Her Majesty's Government ridiculed

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the utility of the electric light in the navy, and yet here we find them actually delaying a ship in order to enable her to be fitted with electric light apparatus. Verily the ways of Government officials are tortuous and past finding out.

A BALLOON AND SIGNALLING CORPS.—It is stated that the formation of the new balloon corps in connection with the Royal Engineers at Chatham is now complete. The officers appointed to the corps are Major Elsdale in command, Major Temple, King's Royal Rifles, and Lieutenant Macdonald, Royal Engineers. The corps will consist of trained telegraphists, riggers, carpenters, and smiths, and they will have a distinguishing uniform. They will, it is understood, shortly leave Chatham.

THE NEW ATLANTIC CABLE.—A Reuter's telegram from New York, dated May 23, says:—"The 'Faraday' has laid a section of the new Atlantic cable from Dover Bay to a point 250 miles from Cape Ann, where the cable was buoyed. The shore end at Rockport was then laid, and the 'Faraday' proceeded to complete the section between that point and Dover Bay." A further telegram, dated May 28, says:—"The section of the new Atlantic cable from Dover Bay to Cape Ann has been completed."

HEALTH EXHIBITION.—Mr. Gooch, electrical engineer at the Health Exhibition, is using Mr. Killingworth Hedges' cut-outs and safety fuses in the machine room, the new galleries, museum, and other parts of the building. The street representing a bit of "Old London" was lighted up for the first time on Saturday by the electric light. The lights were not in view, so that the effect was as if the beams of the moon were falling upon the old buildings. Great satisfaction was expressed with the realistic effect.

RIVER PLATE TELEPHONE COMPANY.—The secretary of the River Plate Telephone and Electric Light Company writes that the settlement of the account with the Consolidated Telephone Construction Company, referred to in the report, having been found to require the confirmation of the shareholders of that company, and the meeting called for the purpose having been adjourned, it has been found desirable to postpone the meeting of this company, fixed for the 29th inst., until after the decision of the Consolidated Company.

LIGHTING GLASSWORKS AT NEW CROSS.—We understand that Messrs. Crompton and Co. have just completed an installation at the glassworks of Messrs. Fitch and Co., New Cross. Here one Bürgin-Crompton compound wound machine is used to supply current to two of the D D arc lamps, as illustrated in our issue of last week, and thirty of the Swan high-resistance lamps, known as 100 volt lamps. The arc and incandescent lamps are run on parallel circuits, which, although not entirely new, is certainly a somewhat novel feature.

FIRE ALARMS IN LONDON.—According to the report of the Metropolitan Board of Works for 1883 just issued, the past year has seen a still further extension of the system of electric fire alarm circuits, which are now an important feature in the machinery of the Metropolitan Fire Brigade. There are 23 fire alarm circuits in operation, the number of points at which an alarm can be given being 151. There are 64 lines of communication by telegraph or telephone between fire brigade stations, 17 between fire brigade and police stations, and 41 between fire brigade stations and public or other buildings.

ELECTRIC LIGHTING AT HAVRE.—A few days since the first trial of electric lights in Havre Docks was made. The large Eure dock is now lighted by Gramme lamps suspended from posts on either side. They can be lowered into the dock, which is a dry one, so as to give light to men working on a ship's bottom or sides, thus enabling work to be carried on by night as well as day, if required. The lamps have an illuminating power of 500 carcels, and will burn for seven hours. The plant was supplied and the installation fitted up by Messrs. Sautter Lemonnier and Co., the well-known electrical engineers, of Paris.

STORMS AND THE TELEGRAPHS.—In the House of Lords on Monday the Bishop of Carlisle moved for a return of the storms which had visited the British Islands between 1st January, 1874, and 31st December, 1883, and of which no warning had been issued from the Meteorological Office, with a notice of the quarter from which each unwarned storm had reached the coast. He pointed out that in 1882 ten storms of which no warnings were given reached our coasts. This was a serious matter, and he trusted that no mere question of money would prevent the increase of our meteorological stations and telegraphs. The motion was agreed to.

CITY GUILDS CENTRAL INSTITUTE.—We regret to hear that Dr. O. Lodge has withdrawn from the Chair of Physics at the City and Guilds of London Central Institution at Kensington, and we hear that Professor W. E. Ayrton, who was not originally a candidate for the chair, has accepted the professorship. It is understood that Professor Ayrton's numerous professional engagements led to his determination not to become a candidate. We think the original determination was a wise one, as we firmly hold that the position of professor is incompatible with that of an ordinary professional adviser. A professorship should be sufficiently valuable both as regards money and social position to render it unnecessary for the holder to mix with business pursuits.

EARTHQUAKE IN SOUTH AUSTRALIA.—A correspondent at Whyte Yarcowie sends the *Adelaide Observer* the following particulars of the shocks of earthquake experienced at that place on April 5:—"The weather was very close at the time (twenty minutes to 2 o'clock), and so very decided was the circumstance that we all looked at each other when seated at dinner to see if any one felt alarmed at a rolling as of heavy stones under our house. The shaking of the table and things upon it sent a most unpleasant sensation through us, and we immediately thought of Sunda and Ischia. Then there was another and more decided shock, which shook our house most perceptibly, and the neighbours ran out of their houses to see what stones had been thrown, or what heavy cavalcade was passing. A beautiful serene and peculiar pink atmosphere spread over our township until nearly 8 o'clock. An exceedingly heavy rain and vivid lightning, with loud peals of thunder, preceded these shocks, which seemed to travel from east to west in a belt, as the inmates of houses on the extreme south and north felt nothing peculiar."

ELECTRIC LIGHTING ON THE EMBANKMENT.—The report of the Metropolitan Board of Works for last year says that "the Victoria Embankment and Waterloo Bridge continue to be lighted by the Jablochkoff Electric Light and Power Company, under an agreement made by the Board with the Company in June 1881 for a term of three years. There are forty lights on the Embankment and ten on Waterloo Bridge, and the payment made is at the rate of 1½d. per light per hour. The Board has on several occasions lately [this presumably has reference to the latter end of 1883] had to complain of the sudden extinction of many of the lights during the hours when the

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company is bound by agreement to keep them shining." Our readers will see on referring to our advertisement columns that tenders are invited for lighting the Embankment and Waterloo Bridge for a further term of years.

THE TELEPHONE IN ENGLAND AND AMERICA.—"J. W. B.," writing to the *Pall Mall Gazette*, says:—Mr. Fawcett last night, in answer to Mr. Gray, stated that the Post Office had been applied to for seventy-seven licences, and they have granted eight. He stated also on the 15th, in reply to other queries, that during the past year they had 954 telephones in use, as compared with 598 in 1883, and 177 in 1882. It may be instructive to compare these figures with those of the Bell Company of America, taken from their last report:—

	Jan. 1, 1883.	Jan. 1, 1884.	Increase.
Exchanges open ...	735 ...	890 ...	165
Miles of wire.........	69,452 ...	82,879 ...	13,427
Subscribers	97,735 ...	123,533 ...	25,798
Employés	3,704 ...	4,777 ...	1,073
Instruments	249,711 ...	307,010 ...	57,299
Gross revenue ...	£315,206 ...	£459,119 ...	£143,913

THE POST OFFICE VOLUNTEERS.—An inspection was held on Friday, May 23rd, at the Charterhouse, where the Manchester, Birmingham, Edinburgh, Glasgow, and Hull detachments Field Telegraph Corps and 24th Middlesex (Post Office) Rifles were formed in full marching order. There were between 130 and 140 of the enrolled telegraphists in the London Central Telegraph Office, besides the contingents from the provinces, on parade. Colonel Du Plat Taylor having made a close inspection, congratulated the men on their appearance, and gave them some practical words of advice. At the close the column, under Sergeant-major Flanagan, marched to head-quarters, where later on those who had volunteered for the Army Field Telegraph Corps were finally examined and enlisted. It will be remembered that some time since the War Office authorised the enlisting of 100 men of this corps into an Army Field Telegraph Corps, fifty for active service and fifty for a reserve.

ELECTRIC LIGHTING IN AUSTRALASIA.—News has just been received that the contract has been let for lighting the magnificent Parliament Houses in Melbourne with electric lights. The contract has been given to the Australian Electric Light Company, with whom the Australasian Company have recently amalgamated their Victorian interests. The installation will provide dynamo power for 1,350 lamps, but probably only 1,000 will be needed at one time. In connection with this the Australasian Company have ordered two Victoria dynamos from the Anglo-American Brush Company. The lamps to be used are Swan lamps. The Australian Company has likewise secured the lighting of the General Post Office at Melbourne. A fine display of electric lighting has just been made at the Victorian Inter-Colonial Exhibition, electric lamps solely being used. A similar installation on a smaller scale was made at the recent Exhibition at Christchurch, in New Zealand, where during the whole period it was open the building was entirely dependent on the electric light.

BLASTING IN CONTINENTAL COLLIERIES.—In the course of an article in the *Colliery Guardian* for May 23 Mr. G. G. André writes as follows:—"The system of exploding a number of shots simultaneously in rock blasting is making its way slowly into common use. It is surprising that a system offering so many advantages should need so much advocacy. Some portion of the prejudice against it is no doubt due to past failures. But the obvious certainty obtained by using powerful currents and the ease with which such currents may be applied when the works are lighted by electricity should be sufficient to induce the disappointed to try again. A good example of the application of the lighting current to the ignition of blasts, and, I believe, the first of its kind, has just come under my notice in Germany. The mine is a colliery, and the surface works are lighted by arc lamps. Underground a stone drift is being driven, and this drift is lighted by incandescent lamps. In the face from twenty to twenty-four shots are placed, and an electric fuse in each is joined up in parallel circuit by means of bare iron wire and connected with the lighting cables in such a way that the current can be shunted from the lamps into the fuses. The result is in the highest degree satisfactory. Misfires are unknown, and the effect is wonderfully good. It is estimated that from twenty-eight to thirty-two shots would be needed if fired in the usual manner in succession; so that the saving of labour is in this case considerable, exceeding 25 per cent., both for the labour of boring and the quantity of explosive required."

THE INSTITUTE OF PATENT AGENTS.—The second annual meeting of the members of this Institute was held on Wednesday at 55 and 56, Chancery-lane. The annual report of the Council stated that since the end of the first financial year, which terminated on April 30, 1883, nineteen new members had been elected. The Institute now comprised fifty-four fellows, two associates, thirty foreign members, and three graduates. During the twelve months that ended on April 30, 1884, the Institute held nine meetings, at six of which papers of interest to patent agents were read. The Institute had been already established on a firm and broad basis, when the whole subject of the laws relating to patents, designs, and trade marks was brought before the House of Commons by a Government Bill presented by the President of the Board of Trade. The Institute had taken an important part in the legislative changes which, by the passing of the Bill in a modified form, became law on the first day of the present year. Other subjects of importance connected with the working of the new Act and Rules, and with the action of the Patent Office, have been dealt with by the Council during the past financial year. The Council congratulated the members on the fact that the Institute has now attained a position which has met with full recognition from the Board of Trade and from the officials engaged in the administration of the Patent Law. With the Board of Trade and the Patent Office the relations of the Council have from the first been of the most satisfactory character, and notwithstanding that the Institute has not yet been in existence for two years, its representations and suggestions have met with a recognition which augurs most favourably for its future career of usefulness. On these grounds the Council now feel justified in inviting the co-operation, as associates, of both classes of members of the legal profession, as well as of engineers, manufacturers, chemists, and others interested in the Patent Laws, and generally in the protection of inventions.

A PHOTOMETRIC STANDARD.—Speaking of M. Violle's standard of light, which has just been adopted by the Electrical Congress held at Paris, and which he states to be the "radiation emitted by a surface of one square centimetre of platinum at its point of solidification," the *Journal of Gas Lighting* remarks: "It is to be accepted, upon M. Violle's authority, that the principle of his standard is correct; and that fused platinum, upon the point of solidifying, will always give the same light during a period convenient for photometrical measurements. This is really all that he has to say on behalf of the standard; for all the other desirable conditions of cheapness, handiness, portability, and facility of reproduc-

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tion, wherever a test may be required, are absent. It must be said that the circumstances amid which the new unit has been devised and accepted are not so satisfactory as they might have been. M. Violle is probably a trustworthy experimentalist; but, all the same, it might have been wished that some independent authority had been entrusted with the tests of his suggested unit. It is scarcely necessary to cite examples to show how the mere suspicion of bias on the part of an experimentalist has vitiated the results of his observations. Here there is every reason to suspect the existence of such prejudice as an inventor naturally entertains for the fruit of his creative brain; and consequently all that he says in favour of the platinum standard will be taken with a great deal of "salt." Briefly, the whole thing has too much the air of being made to order, and taken on trust by the people for whom it was prepared. It is as much a private proprietary article of M. Violle's as though he had patented it; and something more is wanted for the warranty of what is ambitiously styled an absolute unit of light. It remains to be seen whether other photometrists will share M. Violle's admiration of melted platinum. It will be useful to note that, assuming the Carcel lamp to be equal to 9·5 English standard candles, the value of the platinum standard is 19·665 candles; and it is consequently the most powerful unit yet proposed."

American Institute of Electrical Engineers.—Dr. Norvin Green has been elected the first president of this Institute. The first vice-presidents are A. Graham Bell, Charles D. Cross, Thomas A Edison, Geo. A. Hamilton, Charles H. Haskins, and Frank L. Pope. The following gentlemen have been elected managers—viz., Charles F. Brush, William H. Eckert, Stephen D. Field, Elisha Gray, Edwin J. Houston, C. L. Hillings, Frank W. Jones, George B. Prescott, W. W. Smith, W. P. Trowbridge, Theodore N. Vail, and Edward Weston. Mr. Rowland R. Hazard is to be treasurer, and Mr. Nathaniel S. Keith secretary. According to the rules adopted at a meeting held on the 13th inst., the Institute is to consist of members, honorary members, and associates. Members and honorary members must be professional electricians and electrical engineers. Associates are to include persons practically engaged in electrical enterprises, and all suitable persons desirous of being connected with the Institute. Each person desirous of becoming a member or associate must be proposed by at least three members or associates, canvassed by the Council and elected by a majority of the members and associates as expressed by letter ballot to a regular meeting of the Council. The entrance fee is five dollars for each person, and both are to pay an annual subscription of ten dollars per annum. The affairs of the Institute are to be managed by a Council consisting of a president, six vice-presidents, twelve managers, a treasurer, and a secretary. The meeting resolved to appoint a committee of three to take such action as they might deem proper with a view to calling the special attention of Congress to the needs of the Patent Office, as it appeared from a letter communicated to the Institute that the office was so shorthanded that applications for patents would have to wait four months before they could be examined, the examiner being 600 cases behindhand. This, be it noted, is not because the Patent Office is a costly institution, and takes money out of the Treasury chest, for it appears that last year the office made a profit of 471,000 dols.

The Electric Railway at Brighton.—We have from time to time referred to the electric railway which has been constructed at Brighton, through the energy of Mr. Magnus Volk of that town. As our readers may remember, the line is about a mile in length, extending from the Aquarium to Kemp Town, passing under the Chain Pier, which necessitates some heavy gradients, as follow:—

1 in 100	230 yards long.
1 ,, 45	100 ,, ,,
1 ,, 16	50 ,, ,,
1 ,, 30	50 ,, ,,
1 ,, 150	200 ,, ,,

The remainder is practically level. The rails are 20lb. flange and are laid on creosoted sleepers. The current is generated by a Siemens D² machine, driven by a Crossley 8-horse-power gas-engine, consuming about 1,600 cubic feet per day of 11 hours. The cars are driven by a Siemens D² motor (old form), and run at a speed of eight miles per hour. They are fitted with an internal geared pulley, which revolves at the same speed as the axle on the level and all the gradients except the 1 in 16, when by means of a clutch the gearing comes into action and trebles the power applied to the axle, and causes a corresponding decrease of speed. The brake-power of the motor on the level is about 1¾ horse-power. The financial results are most encouraging, the result of the last eight weeks being, acccording to figures which we have every reason to believe are perfectly reliable, as follows:—

Number of passengers, 34,000. Gross earnings, £278 14s. 3d.

Earnings per week, say	£34 15 0
Expenses as enumerated below	17 19 0
Balance	16 16 0

Weekly Expenses.

Driver	£1 4 0	
Conductor	1 4 0	
Station clerk	1 4 0	
Station clerk (female)	0 6 0	
Lineman	1 1 0	
Labourer	0 18 0	
Engine-driver lad	0 12 0	
Electrical and general management	3 10 0	
		£9 19 0
Rent of arch		0 10 0
Repairs, say		1 0 0
Cost of gas at 3s. 3d. per 1,000		1 10 0
Depreciation and interest on £2,500		5 0 0
		17 19 0

The above result has been obtained with one car running about 82 miles per day—say 500 miles weekly, and seating 30 passengers. Two cars will shortly be running, a turn-out being provided half way. The expenses of the second car should not add very greatly to the total cost of working, whilst of course the running capacity of the line will be doubled. We think Mr. Volk is to be congratulated most heartily on the success which has crowned his efforts.

Telephone Exchange Licences.—In the House of Commons on Thursday, the 22nd inst., in reply to Mr. Gray, Mr. Fawcett said:—The number of applications for telephone exchange licences since the institution of the new conditions requiring each company receiving a licence to undertake to sell instruments to the Postmaster-General had been 77, and the number granted had been eight. The new condition was inposed solely for the purpose of protecting the public, and was not intended to check the establishment of telephone exchanges. He had been for some time considering whether with due regard to the public interest it could be in any way modified. As soon as he was in a position to come to a decision on the point, there would be no delay in making it known.—Mr. Gray moved to reduce the vote by the sum of £15,566, being the amount received by the Post Office for royalties from telephone companies during 1883. The hon. member explained the working of the present law relating to telephonic communication, and contended that it was grossly unfair that the royalties to which he objected should be exacted, the Government having attempted to strike at the use of telephonic com-

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munication not in a direct way but by means of a side issue. A few years ago the Postmaster-General granted licences on the mere condition that a royalty of 10 per cent. should be paid. Suddenly he changed his policy, and said he would grant no licences unless the companies who applied for them should sell him as many instruments as he wanted to be used by him for any purpose he thought fit. But neither the parent company nor the subsidiary companies had power to do that, because if they did they would have violated their contracts, and the Postmaster-General knew that very well, for he had in black and white the terms of the contracts between the parent and the subsidiary companies. The policy of strangulation was adopted about two years ago, and not only had remonstrances been made by the companies, but deputations from the various towns waited upon the right hon. gentleman in vain. The people of Plymouth did not understand why they should be refused facilities granted to Manchester, or the people of Cork why they should be refused facilities granted to Dublin. The right hon. gentleman, however, said that the towns which had been left out in the cold should be served by the Post Office or not at all. That was a position which the Postmaster-General would find to be untenable, because the public would not tolerate it. The principle upon which Parliament gave a monopoly to the Post Office was that there should be uniformity throughout the United Kingdom. While the Post Office had been working the telephone during the last two years they had only got 700 subscribers at their various telephone exchanges. For those 700 subscribers they had 5,000 telephone instruments, and so far were they from being apprehensive of the supply of instruments running short that they had been selling them at a profit, and, further, the Post Office, by a contract entered into with the United Telephone Company, had a right to a supply of 15,000 more—that was to say, they had under their control 20,000 instruments in all. That was not protecting the public but destroying the profits of the telephone companies, which earned those profits by making instruments and selling the use of them to subscribers. The action of the Post Office in connection with trunk lines was such as could not be approved. The conditions imposed by the department upon companies who wished to place different towns in telephonic communication by trunk lines, among which conditions was one to the effect that customers must be charged at a rate of 10s. per mile, were so exacting that subscribers could not be obtained, and the public were consequently deprived of the facilities for communications which they ought to have. It had been said that talking stations could be opened in London from which conversations could be held with subscribers at a charge of a 1d. The authorities, however, had refused to countenance the proposal, and the Postmaster-General had said that it could not be entertained even experimentally. The general policy of the Post Office seemed to be to prevent the public from receiving the advantage of telephones, of which the department had less than 400 in the whole of the United Kingdom. He did not intend to bring forward any specific vote, but he appealed to the right hon. gentleman, whose administration at the Post Office had been distinguished in many ways by liberality, to extend that policy of liberality to the telephone question and not to punish the public, because, under a purely technical judgment, he had obtained the right of control.—Mr. Fawcett remarked that some very strong things had been said about the department by the hon. member for Carlow, but he should much regret if any word he said in reply was in any way taken to separate himself from the permanent officials of the department. He alone was responsible for everything that was done. All sorts of charges were brought against the officers of the department as if they had some private motive to serve, but they had no interest except the interest of the Post Office and of the public. It was urged upon him that he should not deal harshly with the telephone exchange companies, and that he should not act on the supposition that they had been consciously acting illegally, and in the exercise of his full legal rights confiscate their property. He was urged to deal in a generous and liberal spirit with them. He had done so. He assumed that the telephone exchanges had been established *bonâ fide*, and he entered into an arrangement that enabled them to continue their business. Consequently in all those towns in which at the time of the decision telephone exchanges were established a licence was granted to them on certain conditions which were agreed to between the companies and himself. The hon. member for Carlow had again and again repeated that he had been actuated by a desire to strangle the telephone companies. Nothing was further from his desire than to do anything unfair towards them. He had had to administer a monopoly, not which the Post Office had bought, for the Post Office had no money, but which had been bought with 10 millions sterling of money of the taxpayers, and he was bound to see that that large expenditure was guarded with adequate precautions. He was a trustee. Suppose a commercial man bought an invention for £100,000, and that he appointed a manager to administer it. Suppose that another patent was taken out for an invention which the courts of law declared to be an infringement. Now, in allowing other people to use that patent, which was an infringement of the one which had been purchased for £100,000, he would refer it to the hon. member whether a manager would not be faithless and not properly careful of his trust if he did not see that the use of the second patent should only take place under conditions which would be adequate to properly safeguard the interests of the first one. That was exactly his position. He was nothing more than a trustee. He was free to confess, as he had stated to the hon. member in the afternoon, that it had been shown by experience that the new condition which he thought it had been necessary in the interests of the public to impose two years ago had checked the development of private telephonic enterprise. He had not intended that this should be its effect; but having ascertained that this was its result, he had been considering for some months—it was a question beset with difficulties and complications—whether he could modify the condition in such a way as to get over the difficulty, while at the same time the interests of the public were properly safeguarded. He could only say that he was willing to repeat that promise.—Mr. Gray thanked the right hon. gentleman for his courteous reply. He had stated that he was bound to protect the public revenue; but he was amazed that no reference had been made by the right hon. gentleman to the deliberate expression of opinion by Parliament in 1878 on this subject. As far as Parliament was concerned, it expressed its desire that the department should not control the telephones. It was to be hoped that the right hon. gentleman would see his way to announce his decision within some reasonably short space of time.—Mr. Fawcett promised that, as far as he was concerned, there should be no unnecessary delay in coming to a decision. The particular point which, he said, had been for some time past engaging and still engaged his attention was the clause in the Telephone Exchange licences which gave the Post Office a general user of the telephones. But what he had said on that point would not apply to the subject of trunk wires, because that question had, as he understood, been settled for the present at any rate. The motion was then withdrawn.

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THE INDUCTION OF CURRENTS IN CORES.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 606, VOL. XII.)

Example 1.—Now let the coil wire and the core be of copper, $\rho = \rho_1 = 1{,}700$, and $\mu = 1$, and take $c_1 = 1$, which is near enough. Also let the core fill the coil opening, making $a = c$, and let this be 1 cm., and the depth $b = 2$ cm. Then

$$w/W = \pi \,.\, 100v^2/1700^2 = v^2/9{,}000 \text{ say.}$$

Thus, by the approximate formula it would require a speed of 95 waves per second to make the core and coil heats equal. This value of the speed, however, with the other data, makes y too large for Y to be altogether left out, and the core heat is really about $\frac{3}{5}$ of the coil heat.

Example 2.—With the same dimensions, let the core be of iron, with $\mu = 100$ and $\rho = 10{,}000$. Here $x = 8v/10$ and $y = 64v^2/100$. We find, by (37), $w/W = \pi v^2/17$. Therefore to get equal heats the approximate formula makes v as low as $(17/\pi)^{\frac{1}{2}} = 2{\cdot}32$ waves per second.

Example 3.—The same iron core, but with $v = 100$ per second. Here the approximate formula makes $w/W = 1848$. But now y is so large that Y must be considered. Its value works out Y = about $\frac{1}{70}$. Consequently $w/W = 1848/70 = 26{\cdot}4$, *i.e.*, 26·4 times as much heat in the core as in the coil. Increasing the size of the core also increases the ratio, with a corresponding increase in the size of the coil. In this last example put $\mu = 1$, *i.e.*, core non-magnetic, but with the same conductivity, then $w/W = \pi/17$ only.

Some remarks need be made concerning the heating of iron cores. In the first place, although the induction may be 100 or more times the magnetic force when the latter is weak, yet the ratio will get smaller and smaller as the force increases. Hence, as in the above calculations μ is treated as a constant, the results are only strictly applicable when the range of the oscillatory current is not so great as, by the magnetisation set up, to alter μ much. Should μ be much altered the strength of the induced current, and the consequent heating, will be correspondingly lowered.

Again, suppose that the oscillatory current in the coil circuit is not the only current there, but consists of variations in the strength of a current of continuous sign. Here evidently the permanent current, by the permanent magnetisation it produces, lowers the value of μ, and the proper value as thus lowered must be taken in the above formulæ. In the extreme, when the permanent current is so strong as to practically saturate the iron, or produce nearly the greatest magnetisation it can legitimately receive under the circumstances, *i.e.*, without mechanical shocks to make the molecules settle into a state indicating a much greater magnetisation under the influence of the magnetising current than it would take unaided, then, unless the oscillatory current is so strong as to undo the work of the permanent current, the changes in the induction will be comparatively small. Let the oscillatory current be a small fraction of the permanent, then μ must be little greater than unity, so far as the variable magnetic force is concerned, and the induced currents and the heating little more than they would be in a non-magnetic core of the same conductivity, *i.e.*, considerably weaker than in a similar copper core.

Professor Hughes says he has discovered that air has a maximum capacity for magnetisation, and that it is equal to that of the purest soft iron. Here evidently, since for μ to be 100 or 50, or whatever it may be, is absurd, the undefined term capacity is used, so far as it is applied to air, to indicate something very different from μ the magnetic permeability. Nor can it be κ, the ratio of the magnetisation to the magnetising force. As the question is one of considerable importance it is to be hoped that Professor Hughes's researches will cast much light upon this and many other little understood parts of magnetic science. In the meantime we may here briefly point out one or two things in connection with saturation and conclusions from the mathematical theory. Let there be a coil, or long slender solenoid for simplicity, containing an iron core, and let a steady current be passing through the wire. The iron becoming magnetised, the action on a magnetic needle outside is increased above what it would be if the core were absent. Increase the current sufficiently, and the iron is said to become saturated, no further increase of magnetisation taking place. This is represented in the theory by supposing the value of μ to fall to unity. If this is practically reached, the core will then, so far as further increase of current goes, behave as if it were replaced by air. The action upon a needle at a distance should still go on increasing, and in proportion to the increase of current above the saturating value. But should the action on the needle stop increasing, or show signs of tending to a limit, not increasing as the current, the conclusion that the magnetisation of the core remains constant is erroneous. It must be decreasing. For our supposed observation shows that the magnetic induction tends to a limit, or at any rate does not increase as it should with $\mu = 1$. Every tube of induction goes through the core (with a correction for the space occupied by the coil), and in the core the induction is the resultant of the magnetic force and of 4π times the intensity of magnetisation, whilst the magnetic force is that due to the current in the coil by the ordinary formula plus the polar force of the magnetisation, which latter may be practically confined to the ends by lengthening the coil. The magnetic force then increasing in the same ratio as the current, and the induction in the air outside by our supposition not showing corresponding increase, the magnetisation of the core must be decreasing, or μ must have fallen below unity in the iron.

It is also obviously suggested that, the iron being removed, the mechanical force on a magnet outside, say on a needle at a sufficient distance to keep its magnetisation constant, may not continue to be proportional to the strength of current when the current is very strong. In this case, keeping to the relation $4\pi\gamma = \text{curl H}$ between the current and the magnetic force, μ also becomes less than unity in the places of strongest force. And as we conclude from the behaviour of, say, copper in a strong field of force that the permeability of the copper is less by a trifle than that of the air enveloping it, if we have μ less than unity in the air it must be still more less than unity in the copper, and probably less than unity in vacuum also with a sufficiently strong current.

The published dynamo formulæ giving relations between the current strength and the E.M.F. are very much alike in this, that if you take away the iron they break down immediately. It is the fact of the magnetisation of iron not being proportional to the strength of current that is made use of to put a stop to the increase of the current when the speed is kept constant. But if μ falls in value in air or vacuum also, it will make the same or similar formulæ applicable to dynamos without any iron, in which present theory indicates indefinite increase of current when the speed is the least above a certain critical value, and the speed is kept constant, with therefore an indefinite supply of power. But we must return to the main subject from these parenthetical speculations.

Coil Current in Terms of E.M.F.—We require to know to what extent the current in the coil is altered by the presence of the conducting core, *i.e.* given the impressed force E sin nt, required Γ in terms of E. We have the equation of E.M.F. in the coil

$$E = R\Gamma + (L - L_1)\dot{\Gamma} + \frac{L_1\rho}{2\pi\mu c}\Gamma' \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)\,bis,$$

where, by (15), $4\pi N\Gamma = H_c$, the boundary value of H, and by equation (25)

$$H = (AM + BN)\sin nt + (AN - BM)\cos nt \,. \quad (25)\,bis.$$

Putting Γ in terms of H in equation (19) we get the two equations

$$\left.\begin{aligned} 4\pi NE &= AP + BQ \\ 0 &= AQ - BP \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (38)$$

in which the new quantities P and Q are given by

$$\left.\begin{aligned} P &= RM - (L - L_1)\,nN + \frac{\rho L_1}{2\pi\mu c}M' \\ Q &= RN + (L - L_1)\,nM + \frac{\rho L_1}{2\pi\mu c}N' \end{aligned}\right\} \quad . \quad . \quad . \quad (39)$$

From (38) we obtain

$$\left.\begin{aligned} &(4\pi NE)^2 = (A^2 + B^2)(P^2 + Q^2) \\ &A = 4\pi N\frac{EP}{P^2 + Q^2} \qquad B = 4\pi N\frac{EQ}{P^2 + Q^2} \end{aligned}\right\} \quad . \quad (40)$$

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A and B being thus known, the current and the magnetic force in the core and the coil current become known at every moment. In equation (29) put for A^2+B^2 its value given by the first of equations (40), and we get

$$(\Gamma)^2 = E^2 \frac{M^2+N^2}{P^2+Q^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (41)$$

giving the amplitude of the coil current in terms of E and known functions, in which r is to be put $=c$.

The current at the time t is

$$\left.\begin{array}{l} \Gamma = (\Gamma) \,.\, \sin(nt-\epsilon) \\ \tan\epsilon = \dfrac{QM-PN}{QN+PM} \end{array}\right\} (r=c) \quad . \quad . \quad . \quad . \quad . \quad (42)$$

where

The angle ϵ determines the difference of phase between the current and the E.M.F.

The full expression for P^2+Q^2 is by (38),

$$P^2+Q^2 = \{R^2+(L-L_1)^2n^2\}(M^2+N^2) + \left(\frac{\rho L_1}{2\pi\mu c}\right)^2(M'^2+N'^2)$$
$$+ \frac{R\rho L_1}{\pi c\mu}(MM'+NN') + \frac{\rho L_1}{\pi c\mu}(L-L_1)n(MN'-NM') \quad . \quad (43)$$

where, besides M^2+N^2 and $MM'+NN'$, for which the expansions have been given, equations (30) and (35), there are two other functions. If many terms are required we may derive the expansions of $M'^2+N'^2$ and $MN'-NM'$ from M^2+N^2 by differentiations. For we have

$$2(M'^2+N'^2) = \frac{1}{r}\frac{d}{dr}\,r\,\frac{d}{dr}(M^2+N^2),$$

as may be proved by equations (26). And

$$MN'-NM' = \frac{1}{2xr^2}\frac{d'}{dr}r^2(M'^2+N'^2),$$

as may also be proved by equation (26). We thus find

$$M'^2+N'^2 = \frac{x^2r^2}{4}\left(1+\frac{3y}{4^26^2}+\frac{10y^2}{4^2\ldots10^2}+\frac{35y^3}{4^2\ldots14^2} + \frac{126y^4}{4^2\ldots18^2}+\ldots\right) \quad . \quad . \quad . \quad . \quad (44)$$

$$MN'-M'N = \frac{xr}{2}\left(1+\frac{6y}{4^26^2}+\frac{30y^2}{4^2\ldots10^2}+\frac{140y^3}{4^2\ldots14^2} + \frac{630y^4}{4^2\ldots18^2}+\ldots\right) \quad . \quad . \quad . \quad . \quad (45)$$

It may, however, according to circumstances, be easier to calculate the values of P and Q separately from equations (39). Of course we must then find the values of M, N, M', and N' separately, the first two by equations (24) and the last two from the expressions obtained by differentiating them.

First Approximation to Effect of Core Currents in Altering Amplitude and Phase of Coil Current.—This we obtain by taking only the first terms of the different series, that is, we consider only the first power of $\frac{1}{\rho}$. How far this will approximate to the truth will depend on the size of y, as illustrated in previous examples. In equations (39) take

$$M=1, \quad N=\frac{xr^2}{2^2}=\frac{\pi\mu nc^2}{\rho}, \quad M'=-\frac{4x^2r^3}{2^24^2}=-\left(\frac{\pi\mu nc^2}{\rho}\right)^2\frac{1}{c},$$
$$N'=\frac{2xr}{2^2}=\frac{2\pi\mu nc}{\rho};$$

they then become

$$P = R - \left(L-\tfrac{1}{2}L_1\right)\frac{\pi\mu n^2c^2}{\rho}, \qquad Q = Ln + R\frac{\pi\mu nc^2}{\rho} \quad . \quad . \quad (46)$$

so that the solution (42) reduces to

$$\Gamma = \frac{E}{\left(R^2+L^2n^2+RL_1\dfrac{\pi\mu n^2c^2}{\rho}\right)^{\frac{1}{2}}}\sin(nt-\epsilon) \quad . \quad . \quad (47)$$

and

$$\tan\epsilon = \frac{Ln}{R+\frac{1}{2}L_1\dfrac{\pi\mu n^2c^2}{\rho}} \quad . \quad . \quad . \quad . \quad (48)$$

This solution (47) and (48) shows that when induction of currents is permitted the retardation of phase is reduced, whilst the amplitude is also reduced. Put $\rho=\infty$ and we have the solution for the case where there is the same core inside the coil, but, by proper division, the currents cannot flow. The reduction in the strength of the coil current from E/R to $E/(R^2+L^2n^2)^{\frac{1}{2}}$ is then due to the self induction, including that due to the magnetisation, and the retardation of phase is $\epsilon = \tan^{-1}\frac{Ln}{R}$. Now (47) and (48) show that, when the induced currents in the core are allowed to flow, and the speed is not so high, or the dimensions so great as to make it imperative to use more terms of the series, the effect on the amplitude and phase of the coil current is the same as if the resistance of the coil circuit were increased

$$\text{from R to } \left\{R^2+RL_1\frac{\pi\mu n^2c^2}{\rho}\right\}^{\frac{1}{2}} = R+\tfrac{1}{2}L_1\frac{\pi\mu n^2c^2}{\rho}$$

approximately, thus reducing the time constant, the strength of current, and the retardation of phase. Many phenomena which may be experimentally observed when rods are inserted in coils may be usefully explained in this manner.

(TO BE CONTINUED.)

OLD CABLE STORIES RETOLD.

BY F. C. WEBB.

THE FIRST CABLE CRUISES OF THE OLD "MONARCH."

In 1852 the Electric Telegraph Company had decided to lay cables from Orfordness to Scheveningen, in Holland, and a company was formed, styled "The International Telegraph Company." This company was practically a mere department of the older company, and the whole concern soon afterwards took the name of "The Electric and International Telegraph Company." Mr. E. Clark was engineer to both companies.

At that time only the Dover and Calais cable had been laid, and it was determined to lay four cables with single conductors instead of a heavy compound cable with four conductors, as not only the risk of loss during laying would be less, but the risk of total interruption when the cables were laid would be less. This proved eventually correct, for during the four years I had charge of the cables only once was there total interruption, and that only for a few hours, when during some operations I broke the last cable by accident at night, but repaired it at dawn of day; whereas, on the other hand, the Dover and Calais cable and Dover and Ostend cables were once broken by the same ship, and total interruption ensued for several weeks, the "Monarch," then with me at Holyhead, having to be chartered by the Submarine Telegraph Company, and brought round to Dover to execute the repairs. But the cables were no doubt too light for the locality, and have since been taken up. Compound cables were laid in their place, which have resulted in total interruption for months; and yet a new compound cable is now about to be laid by the Post Office in their new steamer the "Monarch."

The core for these four "Hague cables," as they were generally termed, was supplied direct to the company from the Gutta Percha Company in Wharf-road—now a part of the Telegraph Construction Company. The iron wire was supplied also direct to the company from Messrs. Tupper and Carr, and the contract for serving and sheathing was given to Messrs. R. S. Newall and Co., who had erected temporary works at the North Dock, Sunderland, where they were making the Ostend cable. All the core was taped, tarred, and sanded previous to its being handed to Messrs. Newall and Co. Most of this work was done by Mr. H. V. Physick, in London, but a part was done by the company, under my direction, with the company's machinery placed in Mr. Newall's works.

I was appointed by Mr. E. Clark to superintend the testing and watch the manufacture at Sunderland. I strongly recommended testing the cables, as manufactured, under water. This was agreed to, and I constructed a dock at Messrs. Newall's works for this purpose. The ground was pure sea-sand, so I determined on wood and concrete. The bottom was made of 9in. concrete, with a layer of tar, pitch, and sand about an inch thick over it. The sides were timber piles, planked and caulked and tarred. The shape was nearly square on plan, with one corner cut off. The dock held water per-

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fectly, in spite of many prophecies to the contrary. The work was carried out by men on time work without any contractors, and only cost about £200.

The cables were manufactured two at a time, and coiled into the dock direct from the machines, the water being kept level with the top of the coils, which were oblong, with a row of piles between them to separate them. On Saturday nights the dock was pumped up full and extra tests taken on Sundays when the cables had been submerged for some hours. To get the water off I used a gutta percha pipe as a syphon over the quay into the harbour. Our tests were of course primitive, but still were more than had previously been taken. For insulation a deflection was taken on a horizontal galvanometer with certain battery power, the deflection with one cell on short circuit being also noted. We had no resistance coils in those days, but as I foresaw we should require some means of testing the distance of a fault I took the deflection on the galvanometer with the cable in circuit with one element as every ten miles was added to the circuit, and tabulated the results, and from these all the faults in the cables for four years were localised with sufficient accuracy for repairs.

These were the first cables tested in their entirety under water before shipment, and the process was not adopted again (except on the Irish cables made at Fenton's Works, Queen's Ferry, near Chester, where I constructed a brick and cement tank) until after the failure of the '58 Atlantic cable. All the welds in the iron wire of the Hague cables were galvanised, a galvanising tank being placed between the machines, and I believe these are the only cables on which this process has been carried out.

By the terms of the contract with Messrs. Newall, the Electric Telegraph Company were to find a ship, and Messrs. Newall to find men; but if I recollect right nothing was said in the contract, which was only on a sheet of note paper, about machinery. The price to be paid for the men was only £500. No payments depended on success in any way. The whole transaction, in fact, was quite different to anything done in the present day. When the two first cables were nearly ready it became necessary to look about for a ship. Lieut. (now Captain) Burstal, R.N., and I were deputed to look out for one. It was decided that a paddle was better adapted for the work than a screw, as when the ship is going slow, with the wind on the beam, the lee paddle helps to keep the ship up to the wind.

After visiting several ports we pitched on the "Monarch," a paddle-wheel steamer of about 500 tons, belonging to Messrs. Brownlow and Pearson, of Hull. The ship had holds less interfered with by beams than anything of the size we had been able to find. The price was £6,200, and to avoid the cost of bankers' commission the accountant of the Electric Telegraph Company was sent down to Hull with the money in notes. Being of a cautious disposition, Mr. Bennett had the notes sewn into the lining of his frock-coat. The next morning after his arrival we went to Messrs. Brownlow and Pearson. Mr. Pearson, who received us, had only one arm, and taking the notes in his only hand he crunched them up in a lump and thrust them into his trousers pocket as if they were so much waste paper, at the same time that Mr. Bennett gave a deep sigh of relief at the end of his responsibility.

I fitted up some machinery for paying out, and Mr. E. Clark and Mr. Robert Stephenson came down to see it. The brake consisted of two horizontal drums at the end of vertical shafts, with certain guides, and one drum could be shifted down suddenly, so as to disengage the cable entirely if necessary in case a kink came, which in those days were our bugbears. Mr. Stephenson did not express much opinion, except that all the places where the men had to stand should be cased in with light iron plating. Mr. Newall, however, claimed to use his own brake, and called mine rubbish, and eventually Mr. E. Clark telegraphed from York to me to remove my brake, saying afterwards to me verbally that it would be childish to dispute about a brake. So mine was removed, and Mr. Newall's placed instead, and I am bound to say that, looking back, Mr Newall's was the best, for mine was made in a great hurry, and the workmanship was not very good. On the other hand, in preparing the holds, of which there were two, I arranged them for paying out from the centre of the coils, which were oblong. But it was argued that the end of the coil was the proper place to pay out from, because that was what had been done before in the "William Hutt" screw steamer when laying the Ostend cable, which had just been laid. The beams I had taken out were replaced, and one at the end of the coils taken out. Further experience has since shown that the centre of the coil is the proper place to pay out from.

Mr. Newall's brake was a vertical drum brake, and with side place for strap on same drum. The drum was in one casting, and the spokes in a separate one secured to the drum by screws. There was a knife to fleet the cable, and a trough to lead the feed cable under it. It was, in fact, the father of the brakes used at the present day, and it always appears to me that Mr. Newall has never received sufficient credit for this design. I am not aware whether it could have been patented, because the knife for fleeting had been used for colliery ropes, but certainly the adoption of it for submarine cables was due to Mr. R. S. Newall.

There was no stern sheave as we have now, but about 10ft. inboard from the taffrail the cable passed over a roller and between two pulleys, and then played freely round the taffrail and side rails over curved castings fitted all round on the rails. This was my arrangement, and was intended to give the cable less power to tug at the stern when growing on the quarter when tide or wind is on the beam, and would tend to prevent the cable in these circumstances affecting the steering of the ship. The Port Patrick and Donaghadee cable had previously been lost by the ship swinging to the cable in a heavy lee-tide. As we know stern sheaves are now adopted, and the cables are so light and the ships so large that the brake-power applied to the cable does not affect the ship's steering much, even with a beam wind and tide. We had no picking-up gear in those days and only two buoys. These were intended to buoy the tag-ends of the shore ends, which, composed as they were of six separate cables and a central wire laid up together, would have three spare ends, even when the four cables were laid. There was no special testing room, and the "board-ship" testing appliances consisted of a vertical galvanometer in gimbals and a single-needle instrument for speaking to shore. When paying out we exchanged signals with shore every quarter of an hour on the single-needle instrument for continuity, and tested for insulation between times with our 288 elements. The deflection was 50° on starting, decreasing to 40° when the cable was all submerged.

It had been determined to lay two of the main cables direct from shore to shore, and lay the shore ends afterwards to save time, as our concession was nearly expiring and the shore ends were not ready.

Accordingly the ship was loaded with one cable, about 130 miles. The cable was coiled into the after-tank first, then back into the fore-tank, and then back into the main-tank, and then into fore-tank again. Thus the ship was never much out of trim when paying out.

We arrived in the "Monarch" off Orfordness on Sunday, May 29, '53, and found there H.M.S. "Adder," commanded by Captain Burstal, which had been specially lent by the Admiralty to assist us, and the "Goliath" tug, of London. Captain Burstal had previously marked the line out by flag buoys all the way across the North Sea from Orfordness to Scheveningen. These buoys were barrels with a mast through them, weighted by a pig of ballast, and carrying a staff and flag, and were the same as those used in the surveying service. They were placed about every ten miles. On board the "Monarch" were Mr. E. Clark, Mr. L. Clark, Mr. Foudrinier (the secretary to the Electric Telegraph Company), myself, and two clerks on the part of the company, and Mr. Spencer and Mr. Thomson on the part of Mr. Newall. Mr. Newall was to meet us at Orfordness, but had not arrived. Doctor (afterwards Sir William) O'Shaughnessy and Mr. H. Vernon Physick, who before had been assistant engineer to the Electric Telegraph Company, came on board, but not to accompany the expedition.

We anchored close to Orfordness, and ran a warp ashore, and waited patiently for Mr. Newall. The wind came on the land, and we buoyed and slipped the end of the hawser, and anchored in Hollesley Bay. On Monday we again anchored close to

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shore. A consultation was held, and as our concession expired in three days if the cable was not laid by that time, Mr. E. Clark determined to proceed without Mr. Newall. We signalled the "Adder" and "Goliath" to get under way. At eight a.m. we had end ashore, and at nine we started. The "Goliath" had us in tow whilst we were weighing anchor, as we were close to the beach, and she continued towing for ten miles, when we cast her off. We left the "Adder" behind to bring off Mr. Thomson (Mr. Newall's engineer), and a clerk who had gone up the river for a sail. We kept some high trees on with Orfordness Lighthouse till lost sight of, which brought us to the first buoy; then we kept the buoy astern, bearing W.N.W., altering our own course so as to keep that bearing on until we sighted the next buoy, which we kept on an E.S.E. bearing, and so on throughout. I attended to the steering of the ship, and Mr. Sargent, a boatswain from the "Adder," attended to the signals from the "Adder," and assisted in steering when I was below. The "Adder" anchored at times, and took set and rate of tide and signalled to us, and she also kept ahead, and when she sighted a buoy placed herself on the line, and made a signal when she was on the bearing, so that sometimes we took her as a mark before we could see the next buoy. Thus the line was regularly ranged out in proper engineering fashion.

Mr. Thomson, as I have said, and one of the clerks not knowing we were going to start, had gone in a boat up the river Alde, and when we were some ten miles out a message came from the lighthouse saying, "Mr. Thomson is now coming down the river." Somebody repeated this on deck, and I recollect exclaiming, "How can you see them at this distance?" I had quite forgotten that we could speak to the shore or the shore to us, as this was my first experience of a message from shore to a ship under way at sea. I can well recollect the strange feeling it gave of novelty at the time. Soon after the "Adder" caught us up, and the clerk had a wigging from Mr. Foudrinier, ending with a "Go forward, sir," in true nautical style. Towards night it came on to blow, and soon increased to a gale from N.E. The tug bore up and ran for Harwich, and had a part of her paddle-box carried away. Mr. Newall had by the evening arrived at the lighthouse, and a series of messages passed between him and Mr. Clark. Mr. Newall told Mr. Clark that he was now responsible for anything that might happen, and Mr. E. Clark replied that the fact of Mr. Newall saying so would not alter the circumstances one way or the other. In the night the "Monarch" was rolling considerably, with a heavy beam sea on. Mr. Spencer had to be lashed near the brake, at which post he kept steadily throughout the work. Down below Mr. L. Clark attended to the testing, and when the rolling compelled a reclining position on the sofa, he had a string fast to the handle of the single needle, at which he tugged every quarter of an hour to give the continuity signal. One of the lanyards of the funnel stays got chafed through by the lifeboat rubbing against it, and the funnel was tottering at every roll. The captain, a very old man, rove a new one, at the peril of having his hand smashed. As the ship rolled to leeward and separated the boat by about four inches from the stay he quickly passed one turn, withdrawing his hand just in time before the next roll brought the boat back on the stay with a thud. I never saw so old a man, and not many young ones, do anything half so smartly. The changes of hold were managed well by Mr. Thomson and a foreman of Mr. Newall's, named Dingwell. In the morning the "Adder" was rolling till we could see her keel. We only missed one buoy in the night. At times, to keep our course when the cable in fore hold was all out, we had the helm hard down for an hour together. As we got near Scheveningen we got a little to the southward of the line, but nothing has been laid across the North Sea as straight as this cable. The distance is 114½ statute miles, and we only paid out 119½.

We anchored just at dusk a little to S.W. of Scheveningen. The next morning I was awoke by Mr. E. Clark coming down, laughing, and telling us all to come on deck, as "there were a lot of penguins alongside." On going on deck we found a Dutch schuyt rolling about at anchor near us, and four or five disconsolate people in oil-skins and sou'-westers sitting in a row on the boom. They were Mr. Ruysenhaars (the *concessionaire*) and some other gentlemen, who, with a zeal for the company's interest, had put off at night to board the expedition, had been unable to fetch us, and had passed a miserable night, without anything to eat, in this most uncomfortable and penguin-like position. We got a ham-bone, some bread and grog to them as soon as we could. I had not had much experience of catering for telegraph ships, and the ham-bone was all that remained; and I was chaffed for many days about that poor bone. We did not get the end ashore until the day after this, and in this work I passed a night rolling about in a schuyt.

The two next cables and shore ends were laid soon after. The fourth was not laid until a year afterwards. When paying out this cable on a dark night, rolling along before the wind and sea, a foul flake occurred. About two tons of cable came up in a great skein, and crashed down the iron saddle, supported about 10ft. high on four 6in. timber legs, just where I had been standing an instant before. A portion of the skein wound round the drum, and of course stopped it dead. The cable streamed out astern towards the horizon. I had a smart foreman with me named Windle (who was afterwards with the Telegraph Construction Company). He got the stray chain of the buoy on the cable, and we just had time to cut the cable with an axe close to the rolling hitch, and away flew the end. Another instant and the cable would have parted. Yet when we came back three weeks afterwards we found the end safe fast to the stray chain.

We had by this time fitted the "Monarch" with our own machinery, including the first single drum picking-up gear ever made. I had four years on and off in the old ship, repairing and altering the course of the cables. The three first cables were laid too close together, but the fourth I laid about ten miles away to the northward of the others. This cable I also took up once and relaid. The fishermen used to hook a cable, heave it up, and let it go again, but during this time they would drift over another, and thus the cables used to come up regularly laid up in places like a rope, and to disentangle them without breaking one of the working cables was the great problem, and it was often very complicated and tedious work. It was very different work to repairing a single cable free from all others. We did not dare to dredge with the ship near a working cable, and I have had many a night in boats being towed to windward by the ship. The tide, too, off Orfordness at springs often runs four knots, and the cables, when lifted on the bight, having been laid quite tight, would not, of course, bear the weight of the ship hanging at right angles to their course. The paddles had, therefore, to be kept going at times fully half speed. When working on such occasions with boats under the bows on a dark night this was always a dangerous job, as there was the chance of a boat drifting into the wheel. I am happy to say I never lost any men, but, soon after I left, one was thus crushed to death in the wheel, and a cable foreman was killed in the picking-up gear.

The old "Monarch," if she could not go fast—about seven and a half knots was her fastest, if I recollect right—could creak to perfection (she was a wooden ship, and twenty-three years old when we bought her). She used to begin with a deep groan below the deepest growl of a Lablache, or a Formes, and then slur up to a note an octave higher than the highest note of a Patti.

We were much bothered, too, by fishing vessels. Once, when re-laying the fourth cable, such a large and closely-packed fleet of fishing vessels were sighted right in our course that I was obliged to deviate the cable round them. At times, too, when steaming out to the buoys their flash lights would crop up under our bows, and as fast as the helm was over one way there was a yell and a light, and we had to put it over the other. We used in spite of all this to lose patent logs, and rarely came into port without finding pieces of nets in our wheels. They used, too, to unshackle our buoys, and then bring them in and claim salvage.

Once when anchored off Scheveningen, in the summer, I brought off from the shore to lunch on board M. Eugene Sue, the celebrated author of "The Wandering Jew." Mr. Maas,

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the owner of the hotel, had introduced me to him, and had told me before I saw him that he answered exactly his own description of his Wandering Jew, as his eyebrows met over the nose. This I found was the case. When coming off in the boat I asked him, amongst other things, if he had read any of Charles Dickens's works, "Oui," he said, "mais je préfère le Sire Valter Scott," which was to me a curious comparison.

It must not be supposed that the "Monarch" was solely engaged on the Hague cables. Two cables from Holyhead to Howth were laid from her and several times repaired. The Firth of Forth and Tay cables we also laid from her, but it would make this article too long to describe any of the work.

During the four years I gradually organised the system of buoys, mushroom anchors, bridles, grapnels, &c., which, with the picking up gear and brake, caused the "Monarch" to be the first ship regularly equipped for cable repairing, and she may consequently be fairly considered the father of the fleet of repairing steamers, amounting to some twenty-five, at the present day.

When I quitted the Company in 1857 I left the four Hague cables all in working order after some heavy repairing work. I telegraphed through from Orfordness to Mr. Weaver at Amsterdam the fact that the last repairs were completed, and I recollect for his reply he sent the words from the last duet in "La Favorite"—"*Va dans une autre patrie cacher ton bonheur.*" Those were the last words I received through the Hague cables, and ended my connection with the cable cruises of the "Old Monarch."*

* Three water colour drawings by me, one representing the old ship laying the first Hague cable in a gale; the second representing her picking up a cable with another crossing it, or what we called "coming to a crossing," and the third representing our boats dredging, hung for many years in the board room of the Electric and International Company. A sketch by me of the "Monarch" paying out in the gale appeared in the *Illustrated London News* in June, 1853.

CORRESPONDENCE.

INCANDESCENCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As the heat intensity or temperature of a flame of a sperm candle or paraffin lamp is practically constant, these form easily reproducible standards with which to compare the temperatures of lamps.

The great difficulty of getting photographic plates of a constant sensitiveness for any special part of the spectrum would, I think, prevent them being used in the manner suggested by "A. D.," on page 591, for temperature comparison.

If your correspondent will turn to page 409, Vol. VIII., of this paper he will there see the spectroscopic photometer we use at Brighton to compare the intensity of differently-coloured lights and their temperatures. In case he should not have access to the number referred to I give the following particulars of the instrument. It consists of a pocket spectroscope of considerable dispersive power (with a scale preferred), having in front of the slit two white planes at right angles to each other, and placed at an angle of 45° to the axis of spectroscope; or, instead of white planes, the ordinary reflecting prism may be used. The planes or prism are placed in a line between the two lights to be compared, so that on looking through the spectroscope two spectra are seen side by side, one belonging to each lamp. These spectra are of course perfectly continuous, *i.e.*, are free from bright lines or spaces because of the light proceeding from solid particles and not gases.

When it is required to compare the temperatures of lamps of the same or different candle-power, each one is first compared to a standard paraffin lamp for future reference, and from this the ratio of one to another is deduced.

The method generally adopted is as follows:—The photometer being placed between the standard lamp A and the incandescent lamp B to be measured, A is moved to or from the photometer until the yellow parts of the two spectra, corresponding to the sodium line D, match each other in intensity. The standard lamp is then fixed in that position, and the distance of B from the photometer is measured and noted. B is now moved to or from the photometer until the blue parts of the spectra corresponding to either the F line of the solar spectrum or the blue strontium line match. The new distance of B is then measured, and the inverse ratio of the squares of these two distances is taken to represent the ratio of the temperatures of A and B. The second lamp C is measured, and the two ratios are compared.

If the spectroscope has a scale the position of the particular blue part of the spectrum to be used for temperature comparison can be definitely fixed, but where there is no scale a pinch of salt in the standard lamp's flame will give the yellow sodium lines, and therefore the part to be used for light comparisons, and a little chloride of strontium the blue line for that for temperature comparison. Theoretically, of course, the above method may not be an absolutely exact one for finding the ratio of two different temperatures—this ratio probably not being exactly proportional to the intensity of the more refrangible part of the spectrum—but some other function (not quite so simple) of this ratio; however, for practical purposes it is sufficiently accurate, and where it is only required to ascertain whether one lamp's temperature is the same as another's it is absolutely exact if properly carried out.—Yours, &c., ARTHUR WRIGHT.

Brighton, May 22.

ARTIFICIAL LIGHT TABLES (COPYRIGHT).

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have so often had occasion to refer to diagrams bearing a striking resemblance to those shown on page 38 of last week's *Electrician* that I hope there is nothing in the law of copyright to prevent me from using my own diagrams, now three years old nearly.

Besides the sunset, sunrise, lighting up and extinguishing curves I have found a "nine-hours' watch" line drawn parallel to (but two hours in front of and seven hours behind) the sunset curve very useful; and the diagram is made still more complete by the addition of the curves for street-lighting, which differ somewhat from those already alluded to, the lamps being kept alight 15¾ hours in winter, and only 5¼ hours at midsummer. The moonlight nights should also be made a note of.

I cannot say who was the first to introduce these corset-shaped figures, but they appear to have been known to the ancients.—Yours, &c., WM. H. MASSEY.

6, Westminster-chambers, London, S.W.

CENTRAL STATION LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In Horrebow's "History of Iceland" there is a chapter headed "Concerning Owls," which only tells us "there are no owls in this island."

In Mr. J. E. Gordon's recent treatise on Electric Lighting, reviewed in your last number, Chapter XIX. is upon "Central Station Lighting," regarding which it is stated, "I had intended to write a long chapter with the above heading, but for various reasons I am not yet prepared to do so."—Yours, &c.,

CAROLUS CLARUS.

ACCUMULATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has been called to your reference to our use of accumulators at our Bristol station in your review of Mr. Gordon's book last week.

I have pleasure in informing you that we have found them in every way successful. They are of the Faure-Sellon-Volckmar type, and have been in constant use day and night for seven months. During that period they have never failed, and the total cost of renewals of plates has been less than one per

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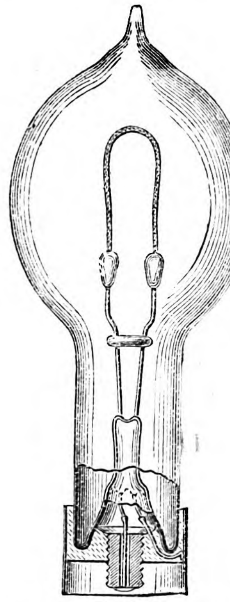
cent. on their cost. By their use we have saved very largely in wages, coal, oil, &c., besides being able to furnish our customers with a constant supply, the light being of course available at any time of the day or night. I may also mention that I have used accumulators in my own house for 21 months, and have found them thoroughly reliable. Indeed, so little attention do they require, that during the past six months the only thing done has been to fill them up with water in February last, to supply the evaporation that had taken place since November.—Yours, &c.,

J. B. Braithwaite, Jun., Chairman.

The Great Western Electric Light and Power Company,
4, Great Winchester-street-buildings, May 29, 1884.

THE BOSTON OR BERNSTEIN LAMP.

When gas superseded the candle and the oil lamp the economy realised consisted not so much in the cheapness of the light-giving material as in the concentration of light. One gas burner gave the light of 12–16 candles. It seems strange that this principle is so little mentioned with reference to incandescent electric lighting. The ordinary Edison or Swan lamp does not give more light than an ordinary gas burner,



The Bernstein or Boston Lamp.

and hence the greater expense of electric lighting. We all know that electric lighting is still in "*statu experimentis,*" but all the adverse criticism can be traced to one common source, namely, to the question of expense. Any improvement in this direction—any lamp which considerably diminishes the expense, if it also meets other requirements—must therefore be hailed with satisfaction, and such an improvement, it is claimed, was shown at the Vienna Electrical Exhibition of last autumn. Most of the incandescent lamps in use up to the present have a fine carbon thread of high resistance, which is brought to incandescence by the passage of the current. They have a comparatively small illuminating surface, and on an average gave a light of 16–20 candles.

The Boston lamp, invented by Mr. Alex. Bernstein, of Boston, Mass., gives a light of from 50–60 candles. A hollow carbon cylinder taking the place of the fine thread, and a larger illuminating surface, but with lower resistance, is hereby obtained. The external appearance of the lamp differs little from that of other lamps, only, as will be seen from the diagram, the carbon cylinder is not directly connected to the platinum wires, but by means of a special cement to two copper wires, which are soldered to the two ends of the platinum wires. The wires are kept in position by being fused into two pieces of enamel; a brass ring and a centre screw, each connected to one of the wires, are firmly attached by plaster of Paris to the lower extremity of the lamp. The brass ring and the central screw are fitted to a specially-constructed lamp holder.

The characteristic part of the lamp, the essence of the Bernstein patent, is made by carbonising a narrow and hollow ribbon of white silk.

The following are the measurements taken by the Scientific Commission of the Vienna Electrical Exhibition, under the presidency of Professor Dr. Kittler :—

Lamp No. 2 (60 Candles Normal).

Experiment.	Amperes.	Volts.	Candles normal	Volt-amperes.
1	3·977	21·588	10·94	85·86
2	4·120	22·286	13·94	91·82
3	4·294	23·120	17·80	99·28
4	4·450	23·880	22·02	106·27
5	4·869	25·894	35·96	126·07
6	5·391	28·387	60·71	151·03
7	5·825	30·445	91·87	177·34
8	6·129	31·776	113·03	194·74
9	6·464	31·372	142·18	202·79
10	6·854	33·018	195·44	226·31

Lamp No. 4 (90 Candles Normal).

Experiment.	Amperes.	Volts.	Candles normal	Volt-amperes.
1	6·582	27·776	27·689	182·82
2	6·988	29·291	37·897	204·68
3	7·694	31·580	56·779	242·99
4	8·360	33·305	88·600	282·61
5	8·540	34·334	95·576	293·20
6	9·251	36·523	138·96	337·87
7	9·286	36·523	150·08	339·15
8	9·657	37·673	180·20	363·81
9	10·701	41·200	287·47	440·88
10	11·226	43·349	344·42	486·64
11	11·831	45·773	467·00	541·60
12	,,	,,	616·52 burned through	,,

Comparing the efficiency of the Bernstein lamp with that of the other incandescent lamps we get the following :—

Name of Lamp.	Candles per H.P.
Lane-Fox	118
Maxim	152
Edison	163
Swan	190
Bernstein	294

ON SOME NEW PHENOMENA IN ELECTROLYSIS.*

BY G. GORE, LL.D., F.R.S.

Whilst making a series of experiments on the "self-deposition of metals" I observed by trying a number of different metals, that several of them received an electrolytic deposit of cadmium by contact with cadmium in various solutions of that metal much more frequently than others; I therefore made various experiments to determine whether this was due to difference of density of current or to other causes. By means of these additional trials I found by passing an undivided current simultaneously through a series of portions of the same metallic solution, that cathodes composed of different metals but of equal amounts of immersed surface, required currents of different degrees of density to cause deposits of the same metal upon them, and that the differences in some cases were considerable. Another singular circumstance was also observed, viz., that the cathode which most readily received a deposit was frequently the one composed of the same kind of metal as that which was being deposited. I am now examining these new facts.

* Read before the Royal Society, May 1st, 1884.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes ... 49
The Induction of Currents in Cores. By Oliver Heaviside. (Continued) ... 54
Old Cable Stories Retold. By F. C. Webb ... 55
Correspondence ... 58 and 59
The Boston or Bernstein Lamp. Illustrated ... 59
On Some New Phenomena in Electrolysis. By Dr. G. Gore ... 59
Deferred Telegrams ... 60
Tubular Carbons for Incandescent Lamps. By M. A. Bandsept ... 61
Note on Hall's Phenomenon. By H. Tomlinson ... 63
The Diameter of Conductors to Prevent Overheating. By G. Forbes. (Continued) ... 63
Telpherage. By Prof. Fleeming Jenkin. (Continued.) Illus. ... 66
Society of Telegraph Engineers ... 69
Companies' Meetings—
Consolidated Telephone Construction and Maintenance Company ... 70
River Plate Telephone and Electric Light Company ... 72
Companies' Share List ... 72

VOLUME XII.

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DEFERRED TELEGRAMS.

Notwithstanding the Postmaster-General's declaration nearly four years ago that he would never sanction such a scheme as that of deferred telegrams, the Society of Arts has again lent itself to the discussion of the scheme, and several well-known agitators who have succeeded before now in imposing their wishes on the Government returned to the charge on Wednesday week with a great show of determination to succeed once again. We will not discuss the motives or the qualifications of these gentlemen, though both might be gravely questioned. Useful and practical suggestions deserve consideration, no matter from whence they may come, and as we are under none of the obligations to silence imposed upon the Post Office officials we will take up the challenge which Colonel Webber threw down to his former colleagues, and discuss the deferred telegram on its merits.

Briefly, what is meant by deferred telegrams considered from Colonel Webber's point of view is that, leaving the existing tariff pretty much as it is, except perhaps as regards free addresses—concerning which, however, the lecturer was not so explicit as he might have been—he would introduce a second class of messages at half price, to be forwarded, not in their turn as handed in by the senders, but only so soon as the full-priced traffic is disposed of. There is a pressure of traffic at certain hours, followed by slackness at other hours of the day, and all through the night, and Colonel Webber wishes to fill up these slack hours at a cheaper rate with messages which are not in such a hurry to be sent. He has discovered that at many offices, numerically the majority, the clerks do not do half an hour's telegraph work all the day long, and this is a picture of idleness which Colonel Webber apparently cannot bear to contemplate. Let the public send deferred messages at half price, and then the wires as well as the clerks would be fully employed. It is awkward for this contention that the class of offices here referred to is precisely that at which there is never any rush of work, where in fact work comes in by driblets and is as quickly disposed of as the facilities will permit. In point of importance this class of office is small, but it actually constitutes the bulk of the whole system, as a glance at any postal guide will show. Now, on such lines there would be practically no difference between a deferred and an ordinary message, except in the price paid for it, and the result would be simply an increase of unremunerative traffic. Some of Colonel Webber's supporters, speaking in the interests of the newspapers, were of opinion that to make an unprofitable business profitable you have only to increase it. This is the theory of the famous apple-woman who lost on every transaction but gained on the quantity. Mr. Saunders and Dr. Cameron may not have had this in mind, but the result held out was the same. It is not to be supposed that the Post Office authorities will invite the sending of messages merely to find occupation for their servants; nor, indeed, are the public likely to respond to such an invitation. If the deferred message is really deferred, the public will not be very anxious to spend sixpence on it when a penny letter would answer nearly as well. But the whole scheme is, we believe, based on a misapprehension. If we are not greatly mistaken, the duties of telegraphy and post office are performed by one and the same class of persons wherever the telegraph traffic is not sufficient to occupy the full time of the officer; and we know that in a vast number of the inferior offices the shopkeepers who have charge of the telegraph treat it as a mere incident of their business, not as a business by itself. The idle telegraph clerk is, we suspect, a creature of Colonel Webber's imagination. There are wires, and plenty of them, that are comparatively idle; but unless extensions are to be refused until there is traffic to fully occupy them this condition is unavoidable. Branch lines would not be filled with traffic even if it were transmitted for nothing. Here again there is a radical misconception. The general public only use the telegraph in urgency; indeed, the same may be said of the commercial public, the difference being only in the frequency of their urgent transactions. To encourage traffic of no urgency whatever, for the mere sake of filling the wires, is to forget the essential object with which all telegraphs are constructed, and to do it at a ruinous cost into the bargain. An idle wire costs nothing; to make use of it always costs something.

Again, as regards local traffic—the internal and suburban traffic of large towns—Colonel Webber supposes that by his

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scheme of deferred telegrams this traffic would be greatly developed. We believe, on the contrary, that if persevered in the system would extinguish all local traffic by rendering it useless. In outlying districts, as we have already mentioned, the deferred message would have a good chance of travelling as fast as any other; but what chance would there be of a deferred town message running the blockade of traffic which it would be sure to meet on its passage from one part of the town to another part? Something may be said for a pneumatic system; but we may remind Colonel Webber that a pneumatic system is not a telegraph system—at its best it could only serve to connect large centres, and would leave the surrounding areas just as they are at present. The craze of people wholly bent on multiplying telegraph traffic is shown in nothing better than in this. The telegraph is an instrument of rapid communication between places widely apart. It is nothing if it is not that. Local telegraphy may occasionally be of some use, but in general it is a delusion; a messenger or a cab would serve as well or better; and as to the deferred telegram for local purposes, the penny post would beat it hollow.

Passing over Colonel Webber's assumption that the traffic of outlying districts, and indeed all traffic except the commercial, is of small importance and might be deferred; as also the manifest error of supposing that a slack period given up to deferred messages would not be used by commercial people for the sake of cheapness, till in course of time there would be no slack period available, and therefore no room for deferred traffic at all, there is only one other argument left to dispose of. It was shown even at the Society of Arts' discussion that no parallel could be drawn between the system of classified messages introduced in our colonial and Indian empires, and prevailing to some extent in the United States, where the distances are so great that the telegraph at its slowest may beat the post by several days at its quickest. But nobody noticed an equally serious mistake of the lecturer in confusing an accelerated message system with a deferred message system. They are in reality totally different. The one is a uniform low tariff, varied by a high express rate for special occasions; the other, Colonel Webber's plan, is a high uniform rate, with a lower one for messages that are not in a hurry. Something may be said for the first, though not much, when the bulk of the traffic is always urgent; but nothing at all can be said for the other, seeing that a deferred traffic on busy lines would suffer intolerable delay, whilst on slack lines the traffic would experience no appreciable relief by deferring a portion of it.

TUBULAR CARBONS FOR INCANDESCENT LAMPS.

BY M. A. BANDSEPT.

(Translation.)

At the present moment considerable interest is being bestowed in the financial world, and particularly amongst electricians, upon an invention which, although not altogether novel, appears destined to exercise a considerable influence upon electric lighting. Incandescence by electricity will certainly furnish the light of the future. Hitherto it has been unable to compete with gas from an economical point of view; but competition will commence in earnest the moment the cost of the new light has been materially reduced. Now, it would appear that the endeavours made to augment the duty of incandescent lamps have been attended with success, and an increase of some 80 per cent. is spoken of. And this important economic result is due to the use of hollow carbons for the production of the light in lieu of the solid filaments of this material ordinarily employed. The question of lighting by incandescence presents, therefore, a new point of interest in relation to the construction of the filaments, which affects in so marked a degree the industrial value of this mode of illumination.

It is understood that electric lighting is simply an application of the heat generated by electric currents, this heat being concentrated in the smallest possible space, so as to produce the greatest possible elevation of temperature. An electric current traversing a conductor raises the temperature of the latter more or less in proportion to the difficulty it encounters in its passage; friction here engenders heat. The temperature depends upon the resistance opposed to the current; and, if the friction is energetic, the heat produced may be considerable in the more attenuated portions of an electric circuit. The luminous intensity increases very rapidly with the temperature; for this reason a refractory body is employed in producing the incandescence.

The essential portion of an incandescent lamp is the carbon filament. It is necessary that the heat due to the passage of the electricity should be very intense, and that it should compensate for the loss of energy due to radiation from the filament.

The work due to the passage of the current is

$$W = E \times C = \frac{E^2}{R};$$

where E is the difference of the potentials at the extremities of the filament,
R the electric resistance,
and C the current.

The equation for work gives the further relation

$$R = \frac{E^2}{W} = \frac{W}{C^2},$$

in accordance with which the dimensions of the filament are determined.

The rule of working (*régime permanent*) of the lamp is given by the equation of equilibrium

$$s = EC = W,$$

in which s represents the radiating surface of the focus.

Let a represent the specific resistance of the carbonaceous filament, *i,e.*, the resistance between opposite surfaces of a cubic centimetre of the material; then the resistance of a cylindrical filament of the length l will be

$$R = \frac{4}{\pi d^2} + l + a$$

or $$W = dl, \text{ whence } l = \frac{W}{d}.$$

The formula given above thus becomes

$$R = \frac{4aW}{\pi d^3}.$$

Whence we have the values

(*a*) $$d^3 = \frac{4aW}{\pi R}$$

(*β*) $$l^3 = \frac{W^2 \pi R}{4a}$$

It is important in the first place to determine the effect of surface and of mass upon the radiating power of an incandescent filament. It is not sufficient to raise the temperature. What is of more importance is to preserve the heat supplied to the carbonaceous filament. Now, for equal masses, the lowering of the temperature is proportionate to the surface of the conductor. With fibres of small dimensions and circumference, the heat does not readily escape, but tends to become accumulated. The best form, from the point of view of the elevation and retention of temperatures, would be that of a sphere. Elongated filaments bent into horseshoe form are, however, generally used, for the luminous arc must have a certain extent of surface, and a certain volume of rays is requisite to produce a highly luminous effect. Intensity (*le titre élevé*) of light is not sufficient. It is only, however, when such

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intensity is obtained that a favourable economic result is realised.

Thus the first principle in the working of incandescent lamps consists in raising the temperature of the carbon filament to as high a degree as the nature of such filament will allow.

This definition shows the importance that should be attached to the means of preserving the essential organ of the light when very thin filaments in which heat is concentrated are employed. The main cause of the destruction of electric carbons is to be found in the motion (*ébranlement*) which accompanies the passage of the current, and which occasions a kind of dissociation, of which the effects are naturally more pronounced as the resistance of the filaments is greater. The deterioration is partly due also to other causes, amongst which may be mentioned the electrolytic (?) action, which has the effect of weakening the filament at that portion where the current enters it.

With the view of conforming to the above-mentioned conditions and to the principle of the variation of the radiating intensity according to the extension of surface and of mass, recourse has been had to tubular carbons. This form allows us to realise an extended surface of incandescent carbon, together with a relatively small mass, and also to combine as far as possible the two opposite conditions of electrical and of mechanical resistance.

But, on the other hand, any great reduction of the mass and of the section has the drawback of diminishing to too great an extent the absolute quantity of heat brought into play, and which is advantageously stored in a latent condition, so as to regulate the irradiation. It became, therefore, necessary to employ, in conjunction with the attenuated filament of carbon, a fly-wheel—so to speak—of light, or, rather, of temperature, in which heat might be stored up and given out according to the variations in the supply. By adopting this means the data of the problem became sufficient, and a complete solution became possible. In fact, by employing as the organ for the light a filament formed of a central thread of refractory substance enveloped in a *thin* layer of carbon specially intended for the production of light, all the conditions necessary for high economical efficiency for the preservation of the filament and for the steadiness of the light were fulfilled. The tubular carbon seems therefore destined to contribute greatly to the much-sought-for solution of the question of economic incandescent electric lighting. Several inventors are occupied in making tubular filaments, and attention has been turned in this direction for several years already. What mention has been made of hollow carbons, however, does not relate to a process of condensing the caloric energy of the currents. The internal armature intended for the formation and preservation of the carbon more often played a completely different part to that assigned to it by theory. This armature should contribute to the accumulation of the heat of the current in the carbon, and should oppose all diffusion towards the interior of the tube. Sometimes it was made of metal, or recourse was had to a metal core covered with an insulating cover, which ended by disappearing, leaving a conducting layer on the interior of the carbon. Thus the first patent relating to filaments with an internal support is dated March, 1882. It mentions incidentally the manufacture of carbons in the form of filaments, by taking very fine metal wire covered with a thin layer of silicate of potash. The water in this layer is evaporated, then the wire is raised to a temperature high enough to separate the carburets of hydrogen or the chlorides of carbon so as to obtain a thick layer of carbon. The inventor adds that it is necessary to oppose the combination of metal wires and alkalies, and that the metal can be preserved in the carbon thus obtained. The last observation shows that it is no question in this case of applying the principle of caloric condensation otherwise than it is applied in solid carbons, since the heat is dissipated through the support or by the metallic layer which exists in the interior of the filaments when the central wire has been made to disappear. Again, whilst the tubular carbons and those furnished with a refractory core lead to an increase in the economy which recent experiments have made known, the process which we have just examined does not afford any increase in the economy of the lamps. It has indeed been found that for an intensity far superior to that generally emitted by incandescent lamps, we only obtain a light of less intensity than that given by the various filament lamps. This fact will be seen from an official report of the committee entrusted with the experiments carried out at the International Exhibition at Munich.

TABLE OF CONSTANTS.

	Maxim.	Edison.	Swan.	Siemens.	Cruto.
Ohm	47·01	139·60	31·91	104·72	8·16
Volt	65·07	103·05	38·38	95·74	22·15
Ampere	1·384	·755	1·222	·915	2·715
Horse-power...	·1224	·1057	·0637	·1191	·0817
Mean intensity	13·34	15·52	10·95	14·90	8·47
Candles per H.-P.	108·98	144·88	171·78	125·14	103·58

If, with these data before us, we compare the economy of the Cruto lamp—the carbon of which is made up by a deposit of dense hydro-carbon (C_4H_4) on a platinum wire, which is subsequently volatilised by the current—with that of Edison for instance, we find that the latter gives about twice the light for the same expenditure of energy. This result is explained by the small specific resistance of the filament of the Cruto lamp and by the loss of heat which occurs owing to metallising of the interior of the carbon.

The first patent which specially claims the use of the tubular form as a means of increasing the temperature of filaments through the accumulation of heat in the carbon is that of M. Somzée, and is dated December, 1882. Tubular filaments are obtained by applying under heat a layer of carbon to refractory wires. To make these wires, magnesia is highly calcined, and when worked up with a solution of acetate of magnesia is brought into the form of a plastic paste. This paste is compressed into a cylinder and drawn out in the shape of flexible wires. These are then subjected to a high temperature at the same time that carbonaceous particles are precipitated on them from dense hydro-carbons forced into refractory pipes. The divided carbon is thus incorporated by occlusion in the solid magnesia. The result obtained is an imperceptible layer of pure carbon adhering to the central refractory wire—that is to say, the electrical resistance most favourable to luminous economy, joined with preservation of the filament, and a mass sufficient to give a steady light. It is hardly possible to have a method which better fulfils the different conditions to be complied with.

The second invention relating to hollow carbons of weak section is that of Mr. Alexander Bernstein. It is known by the name of the Boston lamp. The inventor also proposes to obtain a large surface of carbon having a high resistance. He has accomplised this by curving into horseshoe form a tube of platted silk with thin sides. This tube, placed in a bed of graphite powder, is then carbonised in any convenient mode. Owing to the thinness of the sides the current experiences considerable resistance, and gives rise to an intense luminosity, due to the large surface in a state of incandescence.

Experiments made at the Vienna Exhibition assign to the Boston lamp a duty of 292 candles per electrical horse-power. If we compare this result with the figures obtained for the Maxim, Edison, and Swan lamps given in the preceding table, we find that as far as equality of light is concerned the Bernstein lamp is more economical by about 168 per cent. than the Maxim lamp, 100 per cent. more so than the Edison lamp, and 67 per cent. more than the Swan lamp.

It remains to be seen, however, what is the duration of the lamps, and whether these thin tubes of carbon are not more rapidly injured by the passage of the current. This, however, requires the test of practical use.

From the economical point of view Mr. Bernstein's arrangement is without doubt as rational as that we have just discussed. The layer of air which fills the hollow carbon

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likewise constitutes an insulator. But it is not preserved indefinitely, and it is inconvenient in that it helps to deteriorate the tubular envelope, which it eventually traverses. The hotter the air becomes the more it acquires penetrating power, and easily forces a passage through the enlarged pores and agitated molecules of the carbon. Now, as there is no allowance for the variations of the electric current, nor for those which the changes taking place in the ambient medium determine in the radiation, it follows that hollow filaments are subject to intermittent effects of expansion and contraction corresponding to the different caloric charges accumulated in the wire. Hence a disorganising action which is in accordance with the elevation of the temperature, that is, the reduction of section of the filaments. Under these conditions the economy diminishes as the carbons alter. The addition of a refractory support to the tubular carbon permits of the use of an extremely thin film of carbon. It appears, therefore, to be indispensable.

NOTE ON HALL'S PHENOMENON.*

BY HERBERT TOMLINSON.

In a paper entitled "The Influence of Stress and Strain on the Action of Physical Forces,"† I drew attention to the fact that there is a marked resemblance between the table of "rotational coefficients" drawn up by Professor Hall and that laid down by myself from the results of experiments on the effects of mechanical stress on the specific electrical resistance of metals. A comparison of the two tables given below shows that, with the exception of platinum, the metals stand in nearly the same order in both, and that iron and nickel are very conspicuous, the one at the top and the other at the bottom of the lists. The last-named metal is especially worthy of notice, because in it longitudinal traction, when not carried beyond a certain limit, diminishes the electrical resistance in spite of the increase of length and diminution of section which ensues:—

Name of Metal.	Rotational Coefficient.‡	(a)
Iron	+ 78·0	+ 2·618
Zinc	+ 15·0	+ 2·113
Tin	− 0·2	+ 1·630
Lead	0	+ 1·613
Platinum	− 2·4	+ 2·239
Silver	− 8·6	+ 1·617
Copper	− 10·0	+ 1·005
Aluminium	− 50·0	− 0·420
Nickel	− 120·0	− 8·860

(a) Temporary alteration of specific resistance per unit produced by temporary increase of length per unit. + signifies increase of resistance on application of stress.

It might then be suspected that the results obtained by Hall are capable of receiving an explanation in the fact that the electrical resistance of the strips of metal used by him would be altered by the mechanical strain consequent on their endeavour to move across the lines of magnetic force. Mr. Shelford Bidwell has, however, in his recent interesting communications to the Royal Society and the Physical Society, pointed out that "Hall's phenomenon" cannot be thus accounted for. Nevertheless, as it seems not improbable that there is some indirect connection between the alteration of electrical resistance produced by mechanical stress and the "Hall effect," I have little doubt but that experiments on the "rotational coefficient" of nickel, in which the temperature is varied up to 100° C., or in which the strips are subjected to mechanical traction of varied amount, would assist in deciding the question as to whether purely mechanical stresses are to be regarded as producing the phenomenon. For it has been shown* that with this metal the maximum diminution of resistance following from longitudinal traction is at 100° C. *less than one-half* of that at 15°; and, further,† that whilst traction not exceeding a certain limit produces diminution of resistance, increase of stress beyond this limit is followed by increase of resistance. Hall has remarked, in the *Philosophical Magazine* for September, 1881, that the transverse current obtained with a nickel strip is much *increased*, other conditions remaining unchanged, by rise of temperature. But his experiments in this direction are, I think, hardly conclusive; and, indeed, an examination of the numbers given in the column in which the values of the "rotational coefficient" are recorded shows, in the first *ten out of the eighteen* experiments, evidence that rise of temperature causes a *decrease* of the transverse current. Should Hall's phenomenon prove to result from mechanical strain, I incline to the belief that a rise of temperature from 15° to 100° C. will produce decrease in the transverse current.

The experiments of Mr. Bidwell tend very largely to prove that the "Hall effect" can be explained by the joint action of mechanical strain and certain "Peltier effects." Should this be so, we ought, I think, to be able, by means of two thermo-elements connected with each other and with a delicate galvanometer, one element being in a cooled region and the other in a heated region, to put this theory to the test. Or, again, we might cover the strip with some material of bad thermal conductivity, and watch for a gradual increase of transverse current with time when the electro-magnet is excited, and gradual decrease when the electro-magnetic stress is removed. Indeed, in the actual arrangement adopted by Hall and Bidwell it would seem that this gradual increase or decrease should occur; for though the strips themselves would rapidly cool if unmounted and exposed to the air, the nonconducting material of the mounting would take some little time both to gain and lose the heat imparted to it by the strip.

* Communicated by the Physical Society.

† Phil. Trans., Part I., 1883, p. 168.

‡ A + sign attached to a metal signifies that the effect is in a direction the same as that which the conductor itself bearing the current would follow if free to move across the lines of magnetic force under the action of the ordinary "ponderomotive" force.

* *Loc. cit.*, p. 125. † *Loc. cit.*

THE DIAMETER OF CONDUCTORS TO PREVENT OVERHEATING IN ELECTRIC CURRENTS.‡

BY PROFESSOR GEORGE FORBES.

(CONTINUED FROM PAGE 41.)

We now come to the case of insulated conductors. There are two cases which can be taken together—aerial and subaqueous. The mathematical treatment of these is, however, not quite the same. In the subaqueous cable we may assume that the outside of the insulator remains at the temperature of the water. In an aerial line it sometimes happens that the insulator is so thin that its outside becomes quite hot. The mathematical view of this case is nearly the same as that of a copper conductor covered with lampblack, which case has already been treated.

PROBLEM II.

A conductor of radius r_1 is surrounded with an insulator to an outer radius r_2. If the ratio $\frac{r_2}{r_1}$ remains constant, it is required to find the way in which the current C must vary with radius r_1, so that the temperature of the wire shall be t_1 degrees cent. above that of the outside of the insulator.

Let R, as before, be the specific electrical resistance of the conductor in ohms, and let K be the thermal conductivity of the insulator.

Let H be the heat which is generated per second by the current in a length of one centimetre of the conductor.

Then H is also the heat which flows per second radially out of the insulator per centimetre of length. Imagine the insulator to be made up of a number of concentric cylinders, and let the radius of one of them be r and the thickness δr, then the surface of one centimetre length of this cylindrical shell is

‡ Paper read before Society of Telegraph Engineers and Electricians.

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$2\pi r$; and if $-\delta t$ be the difference of temperature, we have, from Fourier's definition of conductivity,

$$H = -K . \frac{2 \pi r \cdot \delta t}{\delta r}.$$

If we integrate this between the limits $r = r_1$ and $r = r_2$, the difference of temperatures at these points being t_1, we find that

$$\log._e \frac{r_2}{r_1} = \frac{2 \pi K}{H} t_1.$$

Now we also know, from Joule's law, that the heat generated in one centimetre length of the conductor is

$$H = \frac{4 C^2 R}{\pi D_1^2} \times \text{(number of heat units in one watt} = 0{\cdot}24).$$

$$\therefore \log._e \frac{r_2}{r_1} = \frac{\pi^2 K D_1^2}{{\cdot}48 C^2 R} t_1$$

$$C = \sqrt{\frac{\pi^2 D_1^2 \cdot K t_1}{{\cdot}48 R \log._e \frac{D_2}{D_1}}} \quad . \quad . \quad . \quad . \quad (1).$$

It appears from this that when the ratio $\frac{D_2}{D_1}$ is constant the current must vary as the radius of the conductor to produce a constant difference of temperature between the inside and outside of the insulator. But it would be comparatively useless to tabulate the data from this formula, for with aerial cables we must take note of the excess of temperature of the outside of the insulator over the surrounding air. Call this excess t_2. Then, from the method pursued in the investigation for bare wire, E being, as before, the coefficient of radiation and convection, the flow of heat is

$$= \pi D_2 t_2 E ;$$

but it is also

$$= \frac{2 \pi K t_1}{\log._e \frac{D_2}{D_1}}$$

whence

$$\frac{t_1}{t_2} = \frac{D_2 E \cdot \log.^e \frac{D_2}{D_1}}{2 K}$$

putting $E = {\cdot}0003$ (see above) and $K = {\cdot}0005$

$$\frac{t_1}{t_2} = \frac{3}{10} D_2 \log._e \frac{D_2}{D_1} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$\therefore t = t_1 + t_2 = t_1 \cdot \frac{10 + 3 D_2 \log._e \frac{D_2}{D_1}}{3 D_2 \log._e \frac{D_2}{D_1}} \quad . \quad . \quad . \quad (3)$$

and from (1)

$$C = \sqrt{\left\{ \frac{\pi^2 K D_1^2}{{\cdot}48 R} t \times \frac{3 D_2}{10 + 3 D_2 \log._e \frac{D_2}{D_1}} \right\}}.$$

This formula is one of great interest. From it we can calculate directly the value of the current or the rise in temperature when the other quantities are fixed; and all the problems in connection with such cables as are discussed in this memoir can be dealt with by the help of the same formula. There is another matter of great practical importance which it enables us to solve. We can compare it with the formula (A) for bare copper wire. Call I and I′ the currents in bare and insulated wires which with the same value of D give also the same value of t.

Assume $E = {\cdot}0003$ for insulation, and $E' = {\cdot}0002$ for copper.

$$\frac{I^2}{I'^2} = \frac{D^3 t \cdot \frac{\pi^2 E'}{R \times 4 \times {\cdot}24}}{\frac{D_1^2 D_2 \pi^2 K E \cdot t}{2 \times {\cdot}24 \times R} \cdot \frac{1}{2 K + E \cdot D_2 \log._e \frac{D_2}{D_1}}}$$

$$= \tfrac{2}{3} \times \frac{D^3}{D_1^2 D_2} \cdot \frac{1}{2 K} \cdot \left(2 K + D_2 E \log._e \frac{D_2}{D_1} \right)$$

$$= \tfrac{2}{3} \cdot \frac{D_3}{D_1^2 D_2} \cdot \tfrac{1}{2} \cdot \left(2 + \left[\frac{E}{K} = \tfrac{3}{5} \right] \cdot D_2 \log._e \frac{D_2}{D_1} \right)$$

and $D = D_1$.

Thus we find that I is greater or less than I′, according as

$$2 D_1 \left(2 + \tfrac{3}{5} D_2 \log._e \frac{D_2}{D_1} \right) \text{ is } \gtrless 6 D_2.$$

Take as special cases (1) $D_2 = 2 D_1$ and (2) $D_2 = 4 D_1$.

Then I is $\gtrless$ I′ according as

$$(1)\ 4 + \tfrac{6}{5} D_2 \times {\cdot}693 \text{ is } \gtrless 6 \times 2,$$

$$\text{and } (2)\ 4 + \tfrac{6}{5} D_2 \times 1{\cdot}386 \text{ is } \gtrless 12 \times 2,$$

i.e., according as

$$(1)\ D_2 \text{ is } \gtrless \frac{6 \times 2 \times 5 - 20}{6 \times {\cdot}693} \gtrless 9{\cdot}6,$$

$$\text{and } (2)\ D_2 \text{ is } \gtrless \frac{12 \times 2 \times 5 - 20}{6 \times 1{\cdot}386} \gtrless 12{\cdot}0,$$

or (1) as D_1 is $\gtrless$ 4·8 centimetres,

and (2) as D_1 is $\gtrless$ 3·0 centimetres.

We have now arrived at a most important result, viz., that an insulated wire carries a greater current without overheating than a bare wire, if the diameter be not very great. Assuming the diameter of the cable to be twice that of the conductor, a greater current can be carried in insulated cables than in bare wires up to 4·8 centimetres diameter of conductor. But if the insulated cable have a diameter four times that of the conductor, this is the case up to 3·0 centimetres diameter of conductor.

When the thickness of insulation is made very great, the limiting size of conductor which favours the insulated wire is shown below :—

Diameter of Insulator. / Diameter of Conductor.		Limiting Diameter of Conductor which favours Insulation.
2	....	4·8
4	....	3·0
6	....	2·5
8	....	2·2
10	....	2·0
100	....	1·0

I venture to express the conviction that these results must be looked upon as very surprising. It was hardly to be expected that, by surrounding a copper wire with a bad conductor of heat, we could in any case increase the strength of current which it will carry without overheating. Yet such is clearly the case; and the general explanation of it is that by so doing we increase the surface from which radiation and convection takes place. When, however, we have to deal with large currents in large conductors, and the thickness of insulating material is increased in the same ratio, the heat finds greater difficulty in penetrating so thick a mass, and the insulation becomes objectionable from its bad heat-conducting properties, so as to lead us to the result that the bare iron carries more current than the insulated one without overheating, when the diameter is great.

It has been supposed by some persons that heat will escape far more freely through insulating materials, owing to their sometimes being diathermanous, and allowing heat to be radiated through them. Now, in opposition to this view, I must say that very few such substances are diathermanous, and very seldom are they sufficiently homogeneous to allow the possibility of direct radiation through their mass.

Before I go on with what I have to say, I must now pause to make a few remarks on the problem which has just been solved.

1. *Permanent State.*—The definition of Fourier, which has been made the basis of the calculations, has reference to the case only when heat has been steadily supplied for some time, so that the gradation of temperatures from the hot interior and the cool exterior has reached what is called the permanent state. The time which is required to attain this state varies with the conditions of the case. With an insulated cable this time increases with the thickness of the insulating material. It may often happen that many hours must elapse before this

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state is arrived at, *i.e.*, before the calculations of the present part of my paper can be applied. It must be noticed that previous to the establishment of the permanent state the heating effect is less injurious; so that in all cases where there is a considerable amount of insulating material the current may, during the first working hours, be considerably in excess of what has been calculated out here as the working current. The reason of this is, that during this preliminary stage the heat is used up in raising the temperature of the insulating material, which serves to cool the conductor.

2. *Specific Heat.*—This leads me to my second remark about the above calculations, viz., the influence of specific heat of the insulator. It has been explained that, after the permanent state has set in, the heat which is generated in the conductor all passes through the insulator to the external air. But previous to that time the heat generated is partly used up in raising each layer of the insulator up to the temperature which it must have when in the permanent state. The quantity of heat used up in this way depends upon the specific heat of the insulator. The specific heat is the number of units of heat required to raise the temperature of one gramme of the material 1° C. This quantity is known for a large number of substances.

A patent has been taken out for resistances of fine wire through which large currents can be made to pass without undue heating, by embedding the wire in cement or plaster of Paris. The cooling effect of the plaster of Paris is dependent upon its specific heat, and is only temporary. After a very long run of a current through such a conductor, the heating may become greater than in air; and, if the temperature be that of red heat, the plaster becomes a good enough conductor to lower the resistance of the combination so as to make it useless.

I have known of cases where much larger currents have been carried through cables than would be possible by the formula: it is probable in these cases that the current was not continued long enough for the permanent distribution of the temperature to be arrived at. Hence the wire carried a larger current without overheating.

3. Let us form some estimate of the work which is required to heat the insulator to its permanent condition. The exact solution of this problem is troublesome, so we must be content with a very general view of the question. If r_1 and r_2 be the radii of the interior and exterior respectively of the insulator, the mass of this material in a centimetre length is $\pi(r_2^2 - r_1^2)$. Its weight is $w\pi(r_2^2 - r_1^2)$, when w is the specific gravity of the insulator. The heat required to raise its temperature 1° C. is $cw\pi(r_2^2 - r_1^2)$, when c is the specific heat of the material. I can find no determination of the specific heat of gutta percha, but, by the analogy of the substances which it most resembles, it is probably about 0·2. We may take this value for the present, remembering that it is desirable to have experiments made upon all the substances used as insulators, so as to know their specific heats. The density of gutta percha is about 1·0. If we take, as an example, the data derived from an experiment in which $c = 500$, $r_1 = \cdot 625$, $r_2 = 5$, we find

$$cw\pi(r_2^2 - r_1^2) = 0{\cdot}2 \times 1{\cdot}0 \times 3{\cdot}1416 \times 24{\cdot}6$$
$$= 15{\cdot}3 \text{ heat units per centimetre length.}$$

And if it is raised on an average 25° C. it requires 25 × 15·3 heat units per centimetre length to establish the state of steady flow.

Now let us see what time it required to generate this heat with the current of 500 amperes.

The specific resistance of copper is ·000001624 ohm at 0° C., ∴ the resistance of one centimetre length of the specified cable is $\frac{\cdot 000001624}{\pi(\cdot 625)^2}$, and the heat generated by 500 amperes is equivalent to $\frac{\cdot 000001624}{\pi(\cdot 625)^2} \times 250{,}000$ watts per centimetre, or $\frac{\cdot 24 \times \cdot 1624 \times 2\cdot 5}{\pi(\cdot 625)^2}$ heat units per second per centimetre $= \cdot 07943$ heat units per second per centimetre. But the heat required to warm up the insulator to its permanent state is 15·3 heat units per centimetre length per degree cent. Hence, supposing that all the heat generated goes to warm up that insulator, and that none passes through it until the permanent state has been attained, it will take $\frac{15\cdot 3 \times 25}{\cdot 079}$ seconds = 1 hour 21 minutes. It is clear, then, that, since during all this time much heat is passing through, it will be many hours before a current of 500 amperes will be able to heat it as much as is implied by the permanent state.

4. It will be readily believed, from what has been said, how necessary it is to know the thermal conductivity of the insulating material employed in cables. Now, it is very important to notice that the thermal conductivity of substances behaves in the same way as the electrical. The late Principal J. D. Forbes showed that the metals lie in the same order for either conductivity, and that iron becomes a worse conductor for heat at higher temperatures, just as it does for electricity. Now, in the winter of 1872-3, I measured the conductivities of a large number of substances* by an extremely accurate method, consisting of freezing water through them. All the values are less than those which have been obtained by other experimenters at higher temperatures, and the low thermal conductivities of non-metallic substances at low temperatures is completely in accordance with their electric conductivities. It appears, then, that for the high temperatures in conductors the thermal conductivity will be higher, and a larger current can be carried than that given by the formulæ and tables of this memoir.

A few comparisons between the results of Herschel and Lebour, Peclet, and myself will show this.

	G. Forbes.	Herschel.	Peclet.
Marble	·00115 to ·00177	·00470 to ·00560	·0048 to ·0097
Slate	·00081 —	·00315 to ·00550	— —
Vulcanised rubber	·000089	—	—
Vulcanite	·000083	—	—
Caoutchouc	—	—	·00041
Gutta percha ...	—	—	·00048

The average temperature of my results is − 10° C.; that of the others about + 40° C.

5. Another point to be considered is, that when exposed to the air the temperature of the outer surface of the insulator is higher than that of the air. If the cable be in water this is not the case, unless excessive currents be used. The case of a cable in water is the most easy to calculate, and is also the most advantageous in practice, as a larger current can be thus conveyed. When it is further considered that under these conditions gutta percha is practically indestructible, we see that in very many cases it will be advantageous to utilise water-power to generate electricity, and the river bed to carry the conductor to the place where the electricity is to be used.

It has often been noticed that the insulation of leads is unaffected by a few hours' run, but are quite hot and soft after twenty-four or thirty hours. This is completely accounted for by what has now been said.

A general result of this investigation is that an electric insulator should have as high a thermal conductivity and as high a specific heat as possible.

Having now discussed fully the conditions of the problem of a cable in air or water, I have computed a table for wires from 1mm. to 10cm diameter, in which the diameter of the insulated cable is four times that of the conductor (this being, as I find from makers' price lists, a common ratio), showing the current which will raise the temperatures $t°$ C. above those of the surrounding air. [Table A is substituted for one exhibited to the society, as it is of more practical value.]

Subaqueous and Aërial Cables (insulated)—

$$\frac{\text{Diameter of cable}}{\text{Diameter of conductor}} = 4.$$

Temperature of air = 20° C.

t = excess of temperature of conductor over air.

* Proceedings Royal Society, Edinburgh, 1873.

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Computed from the formula,

$$C = \sqrt{\left\{ \frac{\pi^2 D_1^2 K}{\cdot 48 R} . t \times \frac{3 D_2}{10 + 3 D_2 \log._\epsilon \frac{D_2}{D_1}} \right\}}$$

K = thermal conductivity of insulator, = ·00048 for gutta percha; e = coefficient of cooling, = ·0003.

Buried Conductors.—The case of conductors buried underground is difficult to treat mathematically. I content myself with a study of a favourable case, viz., when the conductor takes the form of a thin sheet lying in a horizontal plane under the ground. This form requires far less metal than any other. The heat which is created by the current is at first largely absorbed in heating up the earth near to it, but after some hours a tolerably permanent state sets in, when a very small amount of heat is still penetrating downwards; but the greater part is conducted through the superincumbent earth and paving, and thence cooled by radiation and convection.

TABLE A.

Diameter in centimetres and mills.		Current in Amperes.				
		$t = 1°$.	$t = 9°$.	$t = 25°$.	$t = 49°$.	$t = 81°$.
Cm.	Mills.					
·1	40	3·7	11·0	17·8	24·0	29·5
·2	80	9·1	27·0	43·8	59·0	72·5
·3	120	15·0	44·4	72·1	97·3	119
·4	160	21·2	62·5	102	137	168
·5	200	27·4	81·0	131	177	218
·6	240	33·7	100	164	219	268
·7	280	40·1	119	192	259	319
·8	310	46·4	137	223	301	369
·9	350	52·9	157	253	342	420
1·0	390	59·3	175	285	384	472
2·0	780	124	367	595	803	988
3·0	1180	189	559	908	1225	1503
4·0	1570	254	753	1221	1646	2021
5·0	1970	319	945	1534	2068	2523
6·0	2360	385	1138	1846	2491	3058
7·0	2760	450	1330	2158	2846	3575
8·0	3150	514	1525	2472	3335	4094
9·0	3540	580	1716	2785	3755	4611
10·0	3940	645	1909	3097	4178	5130

With regard to conduction into the soil, we have some experience from the observations which have been made on the temperature at various depths in the soil or in rock. The daily and yearly variations of temperature produce waves of heat in the soil, which are slowly propogated. At a depth of 25 feet the maximum heat occurs in midwinter, and the annual variation of temperature is only $\frac{1}{23}$ of what it is at the surface.

At a depth of two feet the daily variations of temperature are barely perceptible. In the buried cable the heat generated in the dark hours will not all be dissipated at once, but there will be a steady flow of heat at the surface day and night.

(TO BE CONTINUED.)

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The West Indian Panama Telegraph Company is, says the *Pall Mall Gazette*, in rather a curious position. For some time past it has found itself unable to make any profit worth speaking of, and in order to put itself upon a commercial basis it is proposed that the various colonies which it serves should increase the subsidy. All the colonies have agreed except Barbadoes. Until Barbadoes gives way none of the other colonies will grant them an extra penny. If the company were to Boycott Barbadoes all the other colonies would stop their subsidies. The consequence is that matters are in a deadlock. They can neither bring Barbadoes to reason nor carry on without the increased subsidy which Barbadoes vetoes. What the end of it will be no one knows. But it is very hard on the company that a subsidy which they admittedly deserve should be withheld owing to the caprice or obstinacy of a single small island.

TELPHERAGE.*

BY PROF. FLEEMING JENKIN, LL.D., F.R.S.

(CONCLUDED FROM PAGE 43.)

The truck is completed by a small hook or catch embracing the rod. In case of any accident causing the wheels to leave the line this hook will prevent the truck from falling. The weight of the two-wheel stiff truck, shown in Fig. 5, with wrought-iron buckets, is 75lb. The weight of the two-wheel pivoted trucks, with wooden bucket, is 63lb. They are both adapted to carry 2cwt. Fig. 7 shows a one-wheeled truck tested—the results were not favourable. A special form of bucket must be designed to suit such kind of traffic. Simple iron hooks for sacks will, in many cases, be available, and these hooks can be so contrived that on being struck they will drop the sack.

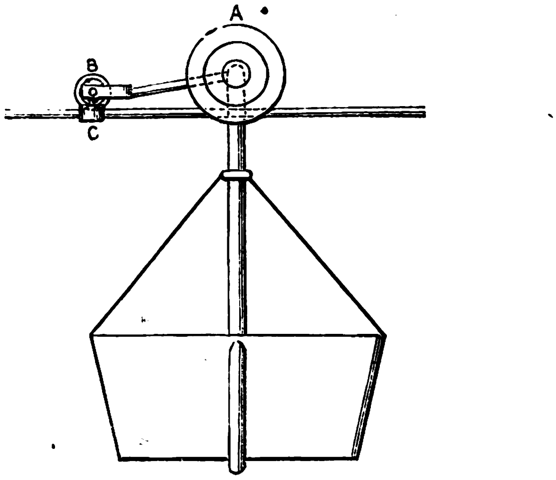
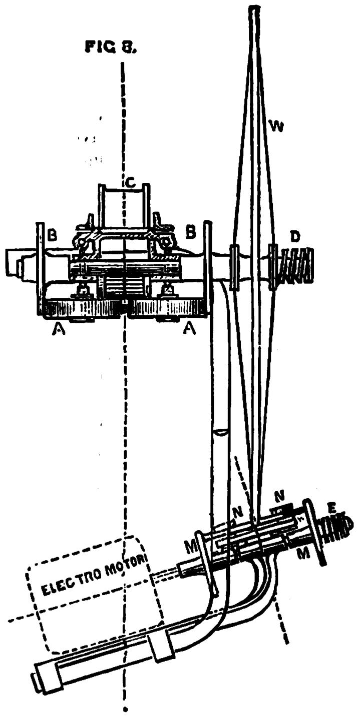


FIG. 7.

The first type of locomotive which was tried on a large scale is shown in Figs. 8 and 9. The motor lies horizontally across the line, and is connected by a form of frictional gearing, which I term right angle nest gearing, with the edge of a bicycle wheel, W. The shaft of the bicycle has on it two discs, B B, one of which is fixed on the shaft, while the other can slide longitudinally on the shaft.

FIG 8.



These two discs are pressed together by a spring, D. Their edges bear on the horizontal gripping rollers, A and A, which seize the line. These rollers are supported in such a way as to be free to come together under the pressure of the spring transmitted by the discs B and B. By tightening the spring any required grip can be obtained with no injurious friction either on the cross shaft or on the spindles of the rollers. This grip is a form of right angle nest gearing. The weight of the locomotive was taken by wheels, C C, fore and aft. The following defects were observed:—The

* Paper read before the Society of Arts, Wednesday, May 14, 1884.

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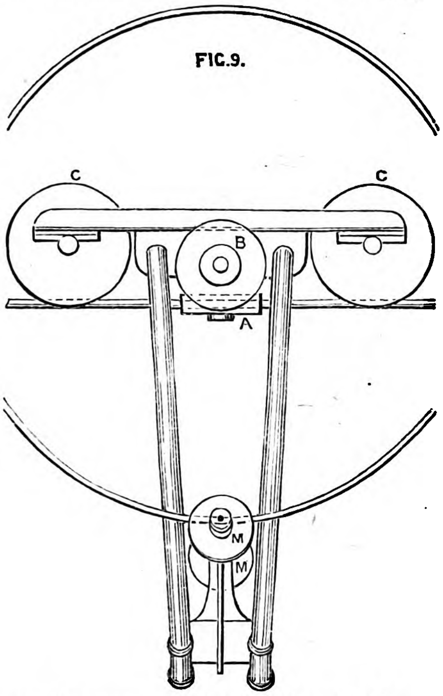
frictional surfaces, both in the upper and lower nests, were too small, and the materials too soft, so that rapid wearing resulted, with a consequent increase of friction. Moreover, the grip was so powerful that the rollers A A were capable of supporting the weight, and thus a small inclination of their vertical axis was enough to cause the locomotive to rise, and even run off the line; moreover, the vertical curvature in the rope or at the posts required the rollers A A to be deep, thus limiting the extent to which rocking was admissible; moreover, very broad pulleys, fore and aft, would be required even for moderate horizontal curves. Nevertheless, this locomotive ran sufficiently well on the 1in. line during an exhibition to the shareholders last autumn. The weight for a five-eight line of a somewhat improved form of this type, to exert one

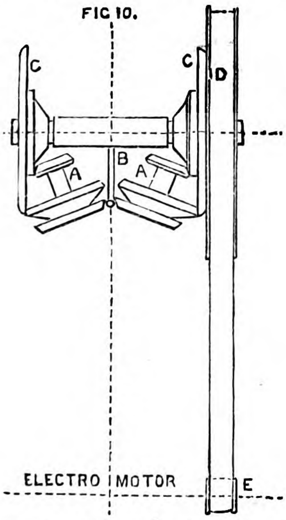
FIG.9.



horse-power, on the average is 200lb. with a half-horse motor. The driving wheels A A of this example are 6½in. diameter. The motor makes 9·23 revolutions for one of the driving wheels. One mile per hour corresponds to 473 revolutions per minute of the motor. 37in. pounds at the motor spindle are required for a pull of 100lb. at the rail.

Figs. 10 and 11 show a locomotive designed by Mr. A. C. Jameson, when I was personally unable to attend to work. This locomotive, which is called the belt locomotive, shows a great advance on its predecessor. The general arrangement of the upper nest grip

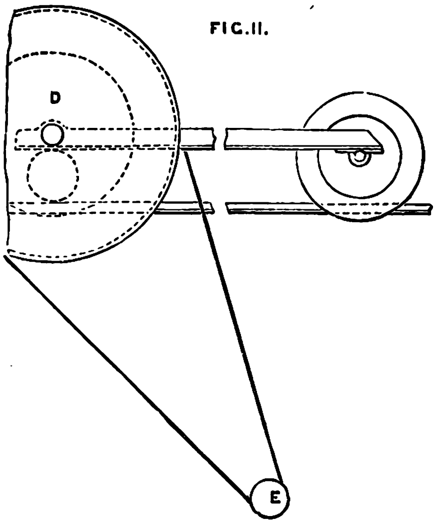
FIG 10.



is retained, but a most ingenious modification has been introduced by which the discs C C run on one path on the rollers A A, while the rod runs on another. In this way the dirt from the line is never conveyed to the driving disc surface between A and C. Moreover these frictional surfaces, which are points in the first form, have become lines in the second. This head answers admirably. The weight is carried by a roller, B, between the gripping discs, an arrangement contained in one of my first small models, and wrongly rejected in the first large locomotive. With this subdivision of weight the gripping wheels are much less likely to rise, and can be made very shallow. In the actual locomotive these gripping wheels are of an open inverted Λ shape, which has certainly run very well, although I prefer at present the upright V shape, which closes under the rail, as used in the model before you. Both of the gripping rollers drive, as in the first type. The cross shaft is driven by a belt on a 20in. pulley, D, the pulley E on the motor spindle. The friction due to the pull of this belt on the motor spindle is relieved by friction rollers. This locomotive runs extemely safely and steadily on the line; indeed, I am not aware that it has ever been thrown off.

The following are particulars of its construction:—Weights with 96lb.; motor, 269lb.; wheel-base, 2ft. 6in.; diameters of driving rollers, 6in.; 4·94 revolutions of motor per one revolution of driving wheel. A couple of 60·6in. lb. on motor is required for 100lb pull at rail; 276 revolutions of motor correspond to one mile per hour on the rail.

FIG.11.



The only improvements I have to suggest in this design are:—1st, the addition of gear, which will give a higher speed of motor for the normal speed of four miles per hour, which we contemplate; 2nd, the addition of a swivel or bogie arm, such as is used in the model before you; 3rd, improvements in the belt connection. Moreover, the machine requires strengthening in some places. It will, however, be seen that none of these points touch the essential features of the design, which might at once be adopted in practice. Worked with motors of the Gramme type, the additional gear would not be required.

Before the belt locomotive had been completed it was necessary to design a locomotive for the South American line, which I have

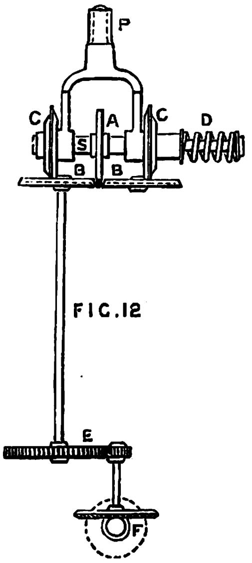


FIG.12

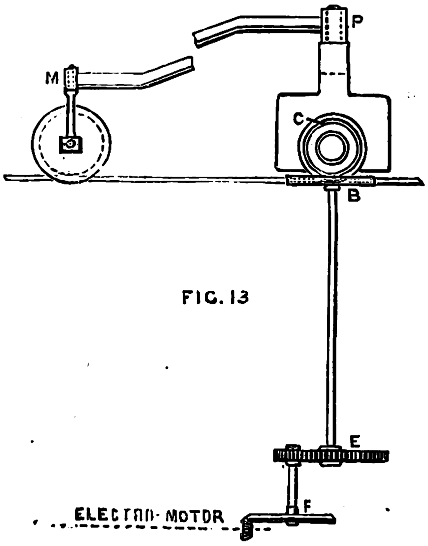


FIG. 13

several times mentioned. I had meanwhile constructed the model which is now before you; and this little locomotive, in which the power is transmitted by ordinary spur wheels, ran so extremely well that I adopted the general arrangement for the next example on a large scale. This arrangement is shown in Figs. 12 and 13, the grip (C C and B B) is a third variety of the right angle nest, simpler than that in the belt locomotive. In this form, also, we have line contacts, and two paths for the discs and rod. Where it is desired to drive from both sides this arrangement is less powerful than that in the belt locomotive. In the South American locomotive

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I drive from one side only, leaving the off side roller free to revolve as it pleases; this avoids grinding at rapid curves, and the adhesion given by one wheel will be ample in a dry country, such as that where this locomotive is to work. The arrangement of the gearing E and F is obvious; it allows the locomotive to lie fore and aft instead of across the line, and this arrangement has some advantages in the adjustment of the weights. The surfaces of the gripping wheels are arranged like an upright V, so as to hold on under the line. This makes it very difficult for the wheels to leave the line, both because of their absolute hold and because the inclination of the V is such as to favour the action of gravitation in overcoming the friction of the grip, instead of opposing it as in the inverted V.

Another feature of this machine is the arm pivoted at P, and carrying the leading wheel, which is again pivoted at M in the arm, as in the case of the trucks. This arrangement allows the locomotive to traverse curves of 6ft. radius—a very remarkable result.

The full-sized locomotive has only just been completed, and run on three spans at Messrs. Easton and Anderson's. So far as I am able to judge from the trial, it is likely to be a complete success. It will be immediately shipped for its destination, so that its performance cannot be more fully tested in this country. The following particulars will show that it is much more powerful than the belt locomotive, but it is considerably heavier:—Wheel-base, 2ft. 6in.; weight, about 3 cwt. 14lb.; 15 revolutions of motor per revolution of driving wheels; diameter of driving wheels, 10in.; 33·3in. lb. per 100lb. pull at rail; 504 revolutions of motor per minute for one mile per hour.

I am in doubt at this moment whether to adopt the belt locomotive or the spur wheel locomotive for the next example. It is simply a question of cost, weight, and durability. Either will do the work.

In all the arrangements it is essential that the second bearing wheel should lead, not follow the drivers in regular work. The reverse arrangement lets the rope lead on at an angle with the plane of the roller, causing an injurious grinding action.

Details of couplings have been well worked out, but space fails for their description.

As general features of the train running on the line, I may mention that the deflection of the rod within reasonable limits has very small influence on the resistance. When the deflection on a 50ft. span was about 2·4ft., the resistance for a train of trucks, weighing in all 1,260lb., was 22lb.; and no sensible difference could be detected when the deflection was materially reduced. This resistance was measured by pulling a train along, span after span, by one end of a rope passing over a pulley on the leading truck, and having a weight hanging vertically from the other end of the rope; the weight thus limited the pull. This pull differs extremely little as the train moves along, for when one part of the train is descending the curve the other part is ascending. It should be noted that during this experiment no special care had been taken to oil the bearings, and I have no doubt this pull can be materially reduced.

I have ventured to dwell at some length on the mechanical problems involved in this form of telpherage, because the experiments made so far have chiefly borne on questions of mechanics. The makers of dynamos can put at our disposal apparatus which will generate day after day, with perfect certainty and regularity, currents of electricity such as will transmit the horse-power generated by powerful steam-engines. These makers have already solved the chief electrical problems which present themselves in connection with telpher lines. They can give us at will constant current or constant electromotive force, high or low, as we may choose. They are now able to arrange their apparatus so that any number of incandescent lamps may be turned off or on without disturbing the regularity with which other lamps are supplied, and by the same arrangement we are enabled to start or stop any number of telpher trains without disturbing the running of others. The electrical problems of the telpher line, and those of electric lighting, run in absolutely parallel lines.

The electric motor, although it may be termed a mere inversion of the dynamo, has not as yet been brought to equal perfection, but month by month improved designs, proportions, and materials are being introduced, and the result already obtained is sufficient for our purpose. It is all the more encouraging to feel that these results will certainly be surpassed, and far surpassed, in the immediate future.

The following short summary of the problem of the transmission of power by means of electricity may interest those who have not studied the subject. There are three steps in this transmission—1st, we convert mechanical power into electricity by means of a dynamo; in doing so we incur a loss of from 10 to 20 per cent. 2nd. This electricity, in flowing along a conductor, generates heat, representing a further loss analogous to that resulting from friction in mechanical gearing. This loss, depending on the distance of transmission, the size of the conductor, and the electromotive force employed, is easily computed. 3rd. We re-convert the electricity into mechanical power by means of an inverted dynamo, which we term an electric motor. With motors in which large weights of iron and copper are employed, the loss in re-conversion need not exceed 20 per cent., but with light motors, weighing from 70lb. to 100lb. per horse-power, such as we must employ in the locomotives, I could not undertake with certainty at this moment to effect the re-conversion without a waste of one-half. The effect of all these sources of loss is, that at the stationary engine I must exert about 3 horse-power for every single horse-power which is employed usefully on the line. I look forward confidently to the time when 2 horse-power at the engine will be sufficient to give 1 horse-power to the motor.

To put these conclusions in a more scientific form, I may assume the efficiency of my dynamo as 80 per cent., that of my light motor as 50 per cent. The waste by heat expressed as horse-power is equal to $\frac{C^2R}{746}$, where C is the current in amperes, and R the resistance in ohms. The horse-power represented by the current is equal to $\frac{E \cdot C}{746}$, where E is the electromotive force in volts, and C the current in amperes. It follows from the last expression that I may increase the horse-power in three ways, by increasing either E or C, or both. If I increase E, leaving C the same, I do not increase the loss during transmission along the line, no matter what horse-power the given line may transmit. A practical limit is set to the application of this law by the difficulty met with in dealing with electromotive forces above 2,000 volts. Marcel Deprez, taking advantage of this law—first pointed out by Sir William Thomson—has transmitted 7 or 8 horse-power over seven or eight miles, through an ordinary telegraph wire, and he obtained a useful duty of 63 per cent., taking into account all the three sources of loss which I have enumerated. With small motors I cannot yet promise a result so good as this, and I merely mention it to let you understand that, in speaking of 3 horse-power for one at the locomotive, I am leaving a very ample margin.

Quitting generalities, I will give some details as to the electrical and other conditions necessary, in two examples, for what may be considered as typical telpher lines:—

First Line.—Length, five miles. Length of circuit, out and in, ten miles. Twenty-five trains running at once, space one-fifth of a mile apart; speed, four miles per hour. Let each require 1 horse-power on the average; let the motor take on the average two amperes of electric current; let the electromotive force near the stationary engine be 840 volts; the electromotive force at the end of five miles will be about 746 volts. The total current entering the line will be fifty amperes at the near end of the line. Fifty amperes and 840 volts represent 56·5 horse-power; of this 6·5 horse-power will be wasted in heating the line; the remaining 50 horse-power will do work in the motors equivalent to 25 horse-power. In order to give this current of fifty amperes with 840 volts, the stationary engine will require to exert $\frac{10}{8} \times 56$ horse-power, or, roughly, 70 indicated horse-power, or somewhat less than three times the useful horse-power. Let us now examine the economical results to be obtained from such a line as this. Mr. Dowson, in an interesting comparison between the cost of horse-power obtained from coal and gas, reckoned the cost per horse-power for a 100 horse-power engine at the rate of £3 6s. 9d. per annum, to include wages, coal, oil, and depreciation. Mr. Dowson would naturally be led to put the cost of steam power obtained from coal rather high than low. I will, however, adopt a very much higher figure, and assume that the power may cost as much as £6 10s. per horse per annum; this gives £455 as the cost of the 70 horse-power required for my telpher line.

Let the 25 trains each convey a useful load of 15cwt. In a day of eight hours the line will have conveyed a traffic which we may express as 600 ton-miles—*i.e.*, it will be equivalent to 600 tons conveyed one mile, or 60 tons on each line conveyed from end to end daily. If we count 300 working days in the year, the sum of £455 gives £1 10s. 4d. per diem, and the 600th part of this is about 0·604 of a penny as the cost of the power required to carry a ton one mile.

In Great Britain we ought easily to be able to reduce this below a halfpenny per ton per mile, which proves that the apparent great waste, even of two-thirds of the power in transmission, does not involve prohibitory expense. In calculating the whole cost of transport, we must further take into consideration the cost of the installation. Taking the spans at 70ft., I estimate this cost as follows:—

Line £500 per mile	£2,500
Engine, boiler, and shed, at £20 per indicated horse-power	1,400
Dynamo and fittings	1,000
Twenty-five trains	2,500
Contingencies	600
Total cost	£8,000

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Allowing 12½ per cent. for interest and depreciation, this represents an annual cost of £1,000. Allowing £100 as the salary of an electrician or young engineer, and adding £455, the cost of the power, this gives a total annual expenditure of £1,555 for a daily duty of 600 ton-miles. If we continue to assume the year as containing 300 working days, the total cost of conveying one ton one mile will be found equal to 2·07d. If goods are to be transmitted for long distances, the same calculation applies. We should simply have stations ten miles apart, working lines five miles long on each side of them. This, then, is the practical outcome of the general principles stated at the beginning of this paper. We may expect with great confidence to being able to convey goods for any distance at the rate of 2d. per ton per mile by the agency of the suspended telpher line.

Matters are somewhat modified when the traffic is smaller. Making similar calculations for a line one mile long instead of five, with only four trains running at once, we might employ an electromotive force as low as 100 volts; the loss by heating would be insignificant; we should require about 12 horse-power; the work done in eight hours would be 96 ton-miles. I estimate the cost of installation at £1,600, and the annual cost of working £344, without the annual salary of an electrician. This corresponds to 2·875d., or less than 3d. per ton per mile. One very important feature in respect to the cost of telpher lines is the fact that the larger part of that cost is due to plant, such as locomotives, trains, and dynamos. This plant can be increased in proportion to the work required; thus there is a very moderate increase of cost in the rate per ton per mile for a small traffic as compared with a large one, and, on the other hand, a line laid down for a small traffic will accommodate a much larger traffic with no fresh outlay on the line itself.

There are numerous minor electrical problems involved, but time does not permit me to enter into the consideration of these to-night. It will be sufficient for electricians when I say that I see my way to governing, blocking, and breaking the trains, without ever interrupting the current used to work the motor, except between the line and rolling wheels. At this point we already know that the interruption, although accompanied by a spark, does no injury whatever. I have often been asked whether the frequent reversals involved in the cross-over system do not tend either to injure the dynamo or the motor. I made special experiments on this very point lately with a compound wound Crompton dynamo and Mr. Reckenzaun's motor with thirty-six coils. I was unable at the commutator of the motor to detect the smallest change in the motion due to the most rapid reversal. At the dynamo commutator I could just see when the reversal occurred, but there was no change of a character to cause the smallest alarm. At the same time I may state that, when from any cause reversals may be thought undesirable, we are in possession of apparatus which we call "step overs," which, without diminishing the simplicity of the permanent way, enable us to send a continuous and unreversed current. These and similar electrical questions, such as the performance of Messrs. Ayrton and Perry's excellent motors, might possibly have had greater interest for electricians than some of the mechanical details discussed to-night; but I have felt that the main point to establish, in bringing this invention before the public, is that we have in telpher lines a means of conveying goods in an economical manner, by lines, locomotives, trucks, dynamos, and motors, which have undergone their preliminary trials with success, and can be at once applied to the more searching test of performing work for the public. If I have established this fact, I think you will have no difficulty in believing that the subsidiary electrical problems have been, or will be, readily solved. I hope that at a future period these will be brought before you in detail on many occasions and by many men.

In conclusion, I will enumerate some of the uses to which telpher lines may be put. They will convey goods, such as grain, coals, and all kinds of minerals, gravel, sand, meat, fish, salt, manure, fruit, vegetables; in fact, all goods which can be divided conveniently into parcels of two or three hundredweight. If it were necessary, I should feel no hesitation in designing lines to carry 5 or 6 cwt. in each truck. The lines will carry even larger weights when these, like planks or poles, can be carried by suspension from several coupled trucks. The lines admit of steep inclines; they also admit of very sharp curves. Mere way leaves are required for their establishment, since they do not interfere with the agricultural use of the ground. They could be established instead of piers, leading out to sea, where they would load and unload ships. With special designs, they could even take goods from the hold of a ship and deliver them into any floor of a warehouse miles away. When established in countries where no road exists, the line could bring up its own materials, as a railway does. Moreover, wherever these lines are established, they will be so many sources of power, which can be tapped at any point, for the execution of work by the wayside. Circular saws, or agricultural implements, could be driven by wires connected with the line, and this without stopping the traffic on the line itself. In fine, while I do not believe that the suspended telpher lines will ever compete successfully with railways, where the traffic is sufficient to pay a dividend on a large capital, I do believe that telpher lines will find a very extended use as feeders to railways in old countries, and as the cheapest mode of transport in new countries. In presenting this view to you, I rest my argument mainly on the cost of different modes of transport, which may, I believe, be stated approximately as follows:—Railway, 1d. per ton per mile; cartage, 1s. per ton per mile; telpher lines, 2d. per ton per mile. And let it be remembered that, in taking the cost of cartage at 1s. per mile, the first cost and maintenance of the road is left wholly out of account; whereas, in my calculations for the telpher line, allowance has been made both for establishment and maintenance.

THE SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS.

At the meeting of this society, the last of the summer session, held at Great George-street on May 22nd, Professor Adams presiding, Mr. W. H. PREECE, F.R.S., past president, gave an account of the proceedings and decisions arrived at by the Paris Electrical Congresses. The chairman first announced with reference to the proposed conference at the Health Exhibition that it had been arranged to commence it at 11 o'clock a.m. on July 3rd, when Mr. Crompton would read an address on "Electricity in Relation to Health," and Mr. Stone one on the "Relation of Electricity to Medical Science." Tickets for admission to the conference would be issued to members of this society. Mr. PREECE then followed, referring first to the Congress of 1881 as a memorable epoch in electrical science, and one reflecting the highest credit on the French Government for their extreme liberality in voting 300,000f. towards the expenses, and on the French nation in general for their capital powers of organisation and the warmth of their hospitality. At this first Congress there were 78 representative French electricians, 38 English electricians, and a like proportion representing other nations. Under M. Cochery's direction chiefly, the work was divided into three sections, a division maintained throughout the subsequent Congresses. First there was one devoted chiefly to telegraphy and telephony, the other two being taken up with electric light, lightning, electrical physiology, electro-metallurgy, and the like subjects.

This gathering in the autumn of 1881 was, however, largely devoted to talk, to clearing the air, so to speak, and to ascertaining the real objects of the Congress. But one thing was practically decided upon, namely, the adoption of the C.G.S. system of measurement, the highest possible compliment that could be paid to the magnificent labours of our own British Association. Several meetings were also held at which the subjects of electric lighting and the electrical transmission of power were fully discussed by the leading electricians of all nations. At the second Congress, held in October, 1882, the attendance was not so numerous, there being about 45 representatives present, of whom only one came from this country. The subjects discussed were earth currents, atmospheric electricity, a proper standard of light, and a fixed one for the ohm. It was finally decided that their further consideration should be postponed in order that observations might be carefully made before the next meeting, which would have the benefit of a greater number of facts to go upon than was then before it. In April of the present year the Congress met again, with a muster of 50 members, including amongst them Sir W. Thomson, Prof. Carey Forster, Prof. Adams, Mr. Graves, Mr. Preece, Prof. Fleeming Jenkin, Prof. Hughes, and Capt. Abney. The result was an agreement with respect to the standard or "legal" ohm, a result which cannot fail to be highly beneficial to electrical research in the future. The legal ohm will now be the resistance of a column of mercury, one square millimetre in section, and 106 centimetres in length, at the temperature of melting ice. We published the particulars of this and the other recommendations of the Congress in our issue of May 10th. With regard to the standard of light fixed upon by the Congress Mr. Preece did not speak very highly. It was adopted, he thought, because no one had a better to suggest.

After reviewing the history of electrical measurement, especially referring to the labours of our countryman, Joule, whose standard differed only slightly from that which has now received an international recognition, Mr. Preece concluded by offering a warm tribute to the French authorities for their kindly reception of the representatives, for their excellent management, and for the zeal with which they promoted and brought to a successful conclusion a work which will prove of lasting benefit to the electrical world. A hearty vote of thanks accorded to Mr. Preece concluded the proceedings.

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COMPANIES' MEETINGS.

Consolidated Telephone Construction and Maintenance Company (Limited).

The third ordinary general meeting of this Company was held on the 23rd inst., at the Cannon-street Hotel, under the presidency of Colonel Gouraud.

The Secretary (Mr. Charles Curtoys) read the notice convening the meeting, and the report of the directors was taken as read.

The Chairman having referred with regret to the absence of Sir Julius Vogel (the chairman of the Company, who is abroad), observed that the first matter which would have struck the eye of the shareholders in the report of the directors, after the necessary reference to the accounts of the Company, was in Paragraph 4, which stated that the results of the working were anything but satisfactory. They had gone on to point to some of the causes which had led to that state of things. They were very few—indeed two circumstances constituted the principal if not the sole causes of these results. All the original shareholders would remember the circumstances under which the Company was formed; but there were a great many among them who were not original shareholders, and it had therefore been necessary to point out that very important feature in the position of the Company. The reference in the report to the Postmaster-General's contract perhaps required a little explanation beyond that given in the report. Those who were thoroughly acquainted with the position of the Company with respect to its contracts knew that the Company stood in a peculiar position. At the time of its formation the United Company was supposed to be the owner of the master patent controlling the use of the telephone; but the Postmaster-General, at the time, with a view to protecting what he conceived to be the interest of the Government under the Telegraph Act, acquired the right to use a large number of telephones—telephones which were made under the patents of the United Company, and a modification—one of an infinite variety of modifications that might be made of the instrument. It was thought by some to be independent of the United Company's patent, and no doubt the Postmaster-General thought so; but what the shareholders of the Company had presented to them was that the Postmaster-General had made a contract implying a very large business. On the other hand this Company at the same time acquired the exclusive right to the manufacture, for the United Company and its subsidiary companies, of all the telephones which they at any time might require. The effect of that combination was that it would appear—and he thought rightly—that this Company stood in the position of being absolutely certain that it would have the manufacturing business of the telephone—of all the telephones used in this country, or that were manufactured in this country for export, the latter provision being also contemplated by the arrangement with the United Company. Well, the business was started, and it seemed impossible to meet the demand for telephones in the early days of the operations of the Company. They were pressed on the right and on the left, both by the Postmaster-General and by the United Company, and though the Company took premises which were at first considered to be adequate, they soon had to remove to larger quarters. During the first period of their business the manufacturing business was very large—so large that the profits derived, quite apart from any business with the United Company, were sufficient from the Postmaster-General's contract alone to pay a substantial dividend on the whole capital of the Company. There suddenly, however, came a check to the business of the Company. From being pressed to deliver beyond the capacity of any manufacturing company so young and engaged in so new a pursuit, there were comparatively no orders—scarcely any from the Post Office, and a little later none at all. That was a serious thing for a manufacturing company. The orders, too, from the United Company were surprisingly small. That state of things unfortunately continued now, and they all very naturally wanted to know why this was. He had that morning taken certain figures from the records of the United Company, and he would give them in comparison with others. They must understand in connection with these figures that the telephone was the telephone in whatsoever country it might be used, for it spoke all languages alike. Any differences in the development of the enterprise, therefore, could not be attributed to the telephone being superior in one place and inferior in another. They all used the Edison and Bell invention in one form or another, and business was all begun about the same time—in this country perhaps a very little later. That day they found, representing all the subscribers of the United Company and its subsidiary companies—which were the only people doing the business to any extent in this country except the Post Office—that there were 10,507 exchange subscribers. That was for all the United Kingdom, for a country with a population of forty millions odd. The private wire subscribers numbered 2,000—that was to say, private wires from one's house to one's works. There were thus seventy-two exchanges, with an aggregate number of 10,507 subscribers, and 2,000 private wire subscribers. If they knew no more than that it might be thought that this represented very good business; and so it was for the people who were doing it. The Post Office had also twenty-five exchanges opened in competition with the United Company, but that was a matter of no concern to this Company, because it was of no consequence who did the business, the Post Office or the United Company.

A Shareholder: How many exchanges have the Post Office got?

The Chairman: Twenty-five; and in the speech of the Postmaster-General last evening he stated that his subscribers numbered about 700. That was the position of the telephone business in this country that day, with the single exception of the business being done by the London and Globe Company; and to be perfectly accurate as to the state of the business in this country he would include that company's operations. That company's business was, he said, to work an exchange in London chiefly, and they had an exchange with, he believed, about 100 subscribers. He would now quote from an official document, dated October last, and the facts mentioned therein were even more astonishing, brought down to a later date. In America, the birthplace of this invention, there were in October last ninety-four exchanges in the principal centres of business, and the figures he had previously given were based on the principal centres of the United Kingdom. The comparison was therefore a fair one. Those ninety-four exchanges were located in commercial centres with an aggregate population of 6,500,000, and they found that the number of the subscribers was 35,360, the ratio to the population being one subscriber for every 188 people. On his way to the meeting he had made a rough comparison to show what that would mean if there had been relatively the same development in this country, which they were, he maintained, reasonably entitled to have; and he had found that they ought to have in London alone 20,000 subscribers, whereas they had under 4,000—in round figures, about 3,500. Those facts bore vitally on the position of the Company. When they came to look for a reason for this result they could find only one. He did not believe that the shareholders any more than the directors would admit that the English people were behind the rest of the world in their intelligence or in their appreciation of a good thing, so that the small progress made in the development of the telephone could not be attributed to that. They believed, in fact, that they could put their finger on the real cause. In the report of the directors they stated that it was owing chiefly to the restrictions imposed on the enterprise by the Government. He did not mean to apply any hostile criticism to the Postmaster-General. They knew, however, the result of the operation of the law, as decided by the Courts, when the companies concluded to admit—from motives of policy rather than from any conviction as to the justice of what they did—that the telephone was in the Postmaster-General's monopoly. Since then they had been subject to the control of the Government, and that had been exercised in one vital respect, with the result shown in the figures he had read to them. The control he referred to was the limit of the operations of the companies' exchanges to the narrow radius of five miles from the centres. Nothing else could explain it. The same restriction did not exist in other countries except in some of the English colonies, notably in India. It was not for him to say that the views of the companies were right on this question and that the Postmaster-General was wrong, but what he had stated must be taken as the cause for the restricted development of the telephone in this country; and he wanted no better authority for that statement than the Postmaster-General's remarks made only on the previous night, and reported in *The Times* of that day. He ought to tell them that during the last two years negotiations had been going on with the Post Office to open this business up and for connecting telephones together. There was no reason why every member of a company should not be able to go into an office and speak to his correspondent anywhere in the United Kingdom except the restriction of the Post Office. Proposals had been made by the companies and counter proposals by the Postmaster-General running over two years. There had been more time spent by the Board of the United Company, and more particularly by the able chairman of the Company, on these negotiations with the Post Office than, he ventured to say, had been spent on any other matter, or on all the other business of the United Company during those two years, and it had only been from the knowledge of their rights and of the value of the enterprise that those connected with the telephone business had stood on their ground. They had refused to accept licences that were prohibitive and involved a large outlay of capital without a prospect of some return on it. On the previous night Mr. Fawcett, in the House of Commons, stated in substance that he had at length arrived at the conclusion that his policy on that point was wrong—and perhaps upon an equally important point he was wrong—and that he would take the question into his early reconsideration. That was the assurance which the Postmaster-General gave to Mr. Gray, to whom his remarks were addressed in reply to questions. The other question was the character of the licences the Postmaster-General had insisted on their taking if they required any more. There were only 72 exchanges in the United Kingdom, and many of these were under the same licence; but for a long time the Government had insisted—and this was a very important point for the shareholders to know—that in any further licences the companies accepting them must agree to sell to the Postmaster-General any telephones they might use at a price to be agreed on, or subject to arbitration. The Postmaster-General, however, was to have the right of buying, whereas he had not the right to buy telephones now except from this Company. He had insisted on buying any telephones from companies accepting the licences now granted, and he did not stop there, for he had also insisted that he should have the right to lease or sell these telephones. They could all see what an encouragement that would be to infringements of patents, and if the patents of the United Company and of this Company were to be infringed in that way—telephones used by any one who might please to use them—then they would have no rights other than those belonging to any other competitor. That was the reason they had done no more manufacturing business. The report of the directors contained no predictions as to the future. The Board determined to give the shareholders all the facts. There was, according to the statement on the previous night of the Postmaster-General, to be a reconsideration of the position as to the telephone, and it might be that the result would be so liberal in the interest of the public that it might give a fair start and fair play to the telephone. The United Company was bound in its contract with this Company to defend the telephone, and it had been doing so with unprecedented success. It had never yet lost an action. If there was to be fair play with respect to the telephone they must have a large business, and if so, and they con-

ducted it properly, they ought to make money. For their contracts, which they had not made much out of in the last two years, this Company paid enormous sums of money. Out of the £137,500 paid for goodwill, patent rights, &c., he supposed—though it would be difficult to fix the exact figure—that it would be right to say that £100,000 was paid for the Postmaster-General's contract.

A SHAREHOLDER inquired to whom the money was paid.

The CHAIRMAN replied to the combination which represented the contract. The other business was the export business. It was to be understood that there was not a very large working capital left—only a little over £50,000, and the Company undertook enterprises which it expected to be relieved of sooner. They had succeeded in this to a certain extent. About a year ago, in order to meet the deficiency shown, a further issue of capital was offered to the public, but it was not sufficiently adequate to support the enterprises in question. As to the Austrian business, on the occasion of their last general meeting the chairman made certain statements concerning its position at the time, informing them that the financial embarrassments of the Company were relieved. They were relieved undoubtedly in so far as the capital coming from the new issue sufficed, but it was only a temporary relief, because the business to which the Company was committed in Austria required more and more money. He was not on the Board at the time the Austrian business was undertaken, but he was perfectly conversant with the views of the Board at the time, and their idea was that with a little money put into the concern and the business started it would be easy to form a separate company for it, and get the necessary capital for developing it. The times, however, had not been favourable to get the capital required. So much for the business in Austria. He went there last summer, and spent some weeks there, and by taking very strong ground with the vendors he improved the position of the Company in this very important respect—that he limited what had been an unlimited liability; and therefore at any rate they knew where they were with respect to that question. His colleague, Mr. Carnegy, reminded him that he ought to tell them that when he spoke of the embarrassments of the Company as to its Austrian business, it was only as to want of capital. He believed that that was so. The business was a very good one. It had practically obtained concessions, which it was very difficult to get, for nine of the principal towns of Austria, excluding Vienna. The business had been started in all these places, and there were a certain number of subscribers at all of them. The only thing the business wanted now was money, and the only actual liability this Company had in respect of the Austrian business was a sum of money which was spent for the account of this Company. That was one of the terms of the compromise he made last summer; but that liability had not yet matured. He had, however, been in communication with the vendors in anticipation of its maturing, and he had, he believed, succeeded in convincing them that it would be to their interest to meet the views of the directors of this Company as to some further modification. Perhaps the most important feature in the report was the item in connection with the River Plate Telephone and Electric Light Company. They had, however, confined their business exclusively to the telephone. That was an affair this Company became committed to when he was not on the Board, but it was in one sense the most fortunate thing this Company had done. They committed themselves to an enterprise in the River Plate of great promise, and one not involving a large amount of original outlay. At the time of assuming this liability they also expected to have the public find the money with which to carry it on, and not unnaturally but most reasonably, particularly as at that time there was a great deal of money forthcoming for electrical business. The Company in question, however, did not come out until the latter part of the ebb time in connection with these enterprises, but the business was so good that the directors of the Consolidated Company, acting to the best of their judgment, and in the interest of the shareholders, supported that Company; and subsequently a further attempt was made to issue capital, with, however, a result very similar to that in the former case—a very small capital subscribed. Meantime it had kept the factory going. The orders coming from the Postmaster-General were practically *nil*, and the material they furnished to the River Plate Company was supplied at very good prices. The telephone business there was almost unique, and this Company had an enormous interest in it. The use of the telephone there in proportion to population was higher than in any other part of the world. He quoted from an official Argentine publication when he stated that the telephone in use in Buenos Ayres represented a ratio of one to every 178 people. That figure represented not only the interest of this Company, but also that of the opposing company, which was neck and neck with them—they had both about the same number of subscribers. That was where a good deal of the Company's money had gone, and "it had gone to a very good place" [laughter]. Well, he wished all the rest of the money was in as good a place; and perhaps it was. The only other outside enterprise the Company had taken—and any one of these was too large for the original capital of the Company if they considered they were going to carry them on themselves — was the Edison-Gower-Bell Telephone Company of Europe, whose business was confined chiefly to the business of telephone exchanges in Lisbon and Oporto. Briefly he might state that the money in that concern was earning very good interest. The capital of the Edison-Gower-Bell Company was altogether out of proportion to the capital in it. Its business was a paying business; there were several hundred subscribers to the exchanges, and they were managed very economically. On the previous day he received a communication from the manager there. He had known for some time that the King of Portugal was anxious to have the telephone extended from town to town, and had been anxious that they should connect Lisbon and Oporto. The communication he had received from the manager stated that a trial had been made the day before the letter was written, with very satisfactory results. There had been a good many changes on the Board of the Consolidated Company, and at the present time the chairman of the Company and one of the directors retired, under the provisions of the Articles of Association. There was not one of the directors who would not have been very glad to resign and give up his position to any one else. They might be able to form some idea of the labours of the Board, contending against the difficulties to which he had alluded; but they did not feel that they could voluntarily offer to go out of office. The consequence was that the names of all the members of the Board were put into a hat, and the names of those drawn out were Sir Julius Vogel and Sir Alexander Armstrong. Sir Julius was in Australia, but they had telegraphed out to know whether they should offer his name for re-election, and he had replied in the affirmative. The report also called attention to the fact that the Board as it stood, including the two who retired, had reached the minimum provided by the Articles of Association. Notice, however, had been given that the names of three gentlemen, members of the Company, would be proposed at that meeting; and he desired to say that he was very glad that there were shareholders who took sufficient interest in the Company to have taken this course. The gentlemen referred to held shares in the Company to an extent which alone entitled them to have a very important voice in the constitution of the directorate, but he was personally unacquainted with any one of them. With regard to the extraordinary general meeting which had been called for that day after the present meeting, he had not told them any of the reasons that had led the Board to make the settlement stated in the accounts as having been made with the River Plate Company, and he would say why he had not done so.

Mr. STOOP rose to order, and stated that notwithstanding that a protest had been sent in against this settlement the chairman had thought fit to announce that a meeting would be held after the present meeting to confirm the action of the Board. He should have thought it would have been more in order if the matter were dealt with at a meeting specially convoked.

The CHAIRMAN said he believed there was no difference between them on this matter, but he thought it was perfectly competent for him to make the remarks he wished to make on the question. He was not going to move the resolution which had been advertised, but was coming to the very question of the protest concerning the proposed settlement. Shortly after the issue of the River Plate Company's report, the Board of the Company received a protest from shareholders demurring to the settlement, and pointing out that in their opinion—he presumed acting on advice—the powers of the directors were not adequate to do what they had done, and that therefore their action was *ultra vires*. It was a matter of some surprise to the directors—not at any one protesting against their views—but that there was any doubt as to the powers of the Board, especially in view of the fact that before the settlement was made it was most anxiously considered. The directors, however, were thankful that someone had pointed out that they were possibly doing something which they had no right to do. No one at the Board had any wish to do anything *ultra vires*, or against the wishes of the shareholders. Under ordinary circumstances they would have called the extraordinary meeting first, and disposed of the matter. As things stood now, when they had asked him questions, he intended to propose the adoption of the report, subject to the adoption of the resolution to be proposed at the extraordinary meeting. He would ask them to elect the directors first, when they would have a Board comprising several gentlemen who had no interest with the Board as a Board, who represented a very large holding in the Company, and whom he believed to be competent in every respect to judge wisely with respect to the resolution to be dealt with at the extraordinary meeting. When they had elected their new Board they would adjourn the meeting, if it were the wish of the meeting that that course should be taken, until the holding of the extraordinary meeting. The reasons which had actuated the Board of this Company in making the settlement with the River Plate Company—which they had stated in the accounts was made subject to the shareholders' approval—were of a nature solely in the interest of this Company. They involved some very peculiar circumstances, but in none of those circumstances was there anything of the nature of a private interest on the part of any member of the Board, or of the Board of the River Plate Company. Unfortunately the directors of the River Plate Company were directors, with one exception, of the Consolidated Company, and there was a provision in the Articles of Association of the Consolidated Company by which it appeared that its directors could not vote on a resolution in which they were interested. The only interest, however, that the directors of the Consolidated Company had in the River Plate Company was that interest which came from their being directors of the Company, and shareholders, only to a small extent. [A VOICE: The directors hold the minimum number of shares in both companies.] He would deal with any question the shareholders might raise after he had finished. He did not give the reasons which had led them to make the settlement, and he desired not to do so; but for no other reason than that he thought it would be most prejudicial to the shareholders' interests that they should be discussed at a public meeting. There was not, however, a single thing which he was not ready to explain to any shareholder or set of shareholders. They must remember that this matter bore on a most valuable asset of the Company, which alone might pull the Company through all its difficulties. He concluded by moving the adoption of the report.

Mr. P. CARNEGY, C.I.E., having seconded the motion,

Mr. STOOP moved an amendment, appointing a committee of shareholders to investigate and report upon the position and affairs of the Company, with full power to call for all books, accounts, documents, &c., belonging to the Company, and adjourning the consideration of the directors' report until after the receipt of the report of the committee; and appointing as the committee, with power to add to their number, Messrs. Henry Grewing (Messrs. Oppenheim and Sons), Arthur Baker (of the Stock Exchange), C. L. W. Fitzgerald (Messrs. F. C. Stoop and Co.),

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John Taylor, and B. G. B. Howden. It was very important for them that the Company should be well managed, on account of the character of the Articles of Association. He was surprised that any honest man could have been found to establish a company with such Articles. He read Clause 90, as follows, observing that the rest of the Articles were equal to it:—"No director, or intended director, shall be disqualified by his office from contracting with the Company either as vendor or otherwise, nor shall any such contract or any contract or arrangement entered into by or on behalf of the Company with any company, corporation, or partnership of, or in which any director shall be a member or otherwise interested, be voided, nor shall any director so contracting, or being such member or so interested, be liable to account to the Company for any profit realised by any such contract or arrangement by reason only of such director holding that office or of the fiduciary relation thereby established; but no such director shall vote in respect of any such contract or arrangement." He contended that that meant that these Articles opened a wide field for the directors taking as much liberty as they liked with the shareholders' money.

Mr. BUCKINGHAM seconded the amendment, and observed that the Company certainly wanted looking into. He could not help thinking that if the Company were properly handled something could be made out of it. He was not sure that the gentlemen at the Board understood the business. The committee was offered in the most friendly way, and he trusted that the directors would not attempt to oppose it, or something very serious would he feared occur. He hoped the committee would go into the question of what was obtained for the £137,500 which had been paid for goodwill and patent rights [A VOICE: To whom was it paid?], and to whom it was paid.

Mr. W. FORD suggested that before they went further the Board should state what course they would take as to the amendment.

The CHAIRMAN said he would at once accept it on behalf of the directors. It seemed to him that he had himself suggested the same course, "only in another way" [laughter].

The amendment was then put and carried unanimously.

After some discussion on the point,

The CHAIRMAN proposed the re-election of Sir J. Vogel, which was seconded by a SHAREHOLDER, but lost on a show of hands.

Mr. C. L. W. FITZGERALD then proposed and the CHAIRMAN seconded the re-election of Sir A. Armstrong, which was carried.

On the motion of Mr. STOOP, seconded by the CHAIRMAN, Messrs. H. Grewing, A. Baker, and C. L. W. Fitzgerald were elected directors.

It was decided to defer the question of the election of auditors until the committee's report had been received.

The CHAIRMAN then announced that the general meeting stood adjourned.

The SECRETARY next read the notice convening the extraordinary meeting, but

On the motion of Mr. BAKER it was adjourned.

A vote of thanks to the chairman was afterwards passed, and the proceedings then terminated.

River Plate Telephone and Electric Light Company (Limited).

The general meeting of this Company, originally fixed for the 8th inst., and subsequently adjourned to the 29th inst., was further adjourned, pending the report of the committee of shareholders appointed at the meeting of the Consolidated Company, under the circumstances referred to in our report of the proceedings at the meeting of the latter company. It is stated that a further notice will be issued "calling a meeting at the earliest possible moment after the adjourned meeting of the Consolidated Company."

TO BE SOLD BY TENDER, in four lots, pursuant to an order of the Honourable Mr. Justice Pearson made in an action "Pedley v. Rogers and others," with the approbation of the judge, certain ENGINES, Machinery, Dynamos, and other Electrical Appliances and goods, situate at 57, Wellington-road, Barnsbury, in the county of Middlesex. Tenders are to be sent to Mr. Arthur Cooper, of 14, George-street, Mansion House, E.C., the Receiver in the said action, not later than JUNE 2, 1884, when they will be duly considered and be subject to the approval of the Judge at Chambers on Monday, June 16, at twelve. Catalogues and conditions of sale and forms of tender may be had of Messrs. West, King, Adams, and Co., 66, Cannon-street, E.C., Solicitors; of Messrs. Rogers and Chave, 3 and 4, Great Winchester-street-buildings, E.C., Solicitors; of Messrs. Pedley and Bartlett, of 23, Bush-lane, E.C., Solicitors; and of the Receiver. The Property may be viewed on 28th, 29th, and 30th May, 1884.

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COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. May 28.		Business Done Week Ending May 28. Highest.	Lowest.
Anglo-American	31½,	32½	32¼	31⅝
Do. Preferred	58,	59	58½	57½
Do. Deferred	6¾,	7¼	7 5-16	7
Brazilian Submarine	9⅞,	10⅜	10¼	10
Cuba	9¾,	10¼	10⅛	—
Do. Preference	16½,	17½	—	—
Direct Spanish	4½,	5	—	—
Do. Preference	14¼,	14¾	—	—
Direct United States Cable	9¾,	10	10	9¾
Eastern Telegraph	10⅞,	11⅛	11 1-16	10¾
Do. 6 per Cent. Preference	13,	13½	13 9-16	13½
Do. 5 per Cent. Debentures, 1899	103,	107	—	—
Eastern Extension	11⅜,	11⅝	11½	11 7-16
German Union	9¾,	10¼	10	—
Globe Telegraph and Trust	6½,	6¾	6⅝	6 7-16
Do. Preference	12¼,	12½	12 9-16	12⅜
Great Northern	13⅝,	13⅞	13¾	—
Indo-European	30½,	31½	—	—
Mediterranean Extension	1¼,	1¾	—	—
Do. Preference	2,	4	—	—
Reuter's	8,	8½	—	—
Submarine	150,	160	157	—
West India and Panama	⅞,	1⅛	13-16	—
Do. 1st Preference	6¾,	7¼	7	6⅞
Western Brazilian	5¼,	5⅝	5 7-16	5⅜
Western Union 7 per Cent. 1st Mortgage	121,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	106	—	—

TELEPHONES.

Companies.	Closing Prices. May 28.		Highest.	Lowest.
Consolid. Telephone and Maintenance	⅛,	¼	—	—
Oriental	⅛,	⅜	3-16	—
United Telephone	7¾,	8¼	8 3-10	7 15-16

ELECTRIC LIGHT.

Companies.	Closing Prices. May 28.		Highest.	Lowest.
Anglo-American Brush Light (£7 paid)	1⅝,	1⅞	1 15-16	1 3-16
Do. (fully paid)	3½,	4	3½	—
Hammond Light (£3 15s. paid)	½,	¾	4-16	⅝
Eastern Electric (£4 paid)	—	—	—	—
Swan	⅝,	⅞	13-16	11-16
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Companies.	Closing Prices. May 28.		Highest.	Lowest.
Telegraph Construction	—	—	33¾	33½
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23¾	—

ELECTRIC LIGHTING.

The METROPOLITAN BOARD OF WORKS is prepared to receive TENDERS for the LIGHTING by ELECTRICITY of the VICTORIA EMBANKMENT and WATERLOO BRIDGE during Three Years from the 1st of July next. The number of lamps to be lighted is fifty, forty being on the Embankment wall, extending from Westminster to Blackfriars, and ten on Waterloo Bridge.

The lamps are required to be lighted during six hours (beginning at sunset) on every day throughout the year.

Persons tendering must state what mode of electric lighting they propose to adopt, and the price per lamp per hour for which they are prepared to undertake what is required.

The person or persons whose Tender may be accepted will be required to enter into a contract for the due fulfilment of the undertaking.

Tenders must be addressed to "The Clerk of the Metropolitan Board of Works, Spring Gardens, S.W.," and be delivered at this office not later than 4 o'clock on THURSDAY, the 12th of June, after which time no Tender will be received.

The Board does not bind itself to accept the lowest or any Tender.

J. E. WAKEFIELD,
Clerk of the Board.

Spring Gardens, S.W.,
22nd May, 1884.

ELECTRICAL ENGINEER, speaking four languages, good experience, good references, seeks engagement. Terms moderate; manufactory preferred. Would give important invention for good situation.—Letters to F. PORTER, Wool Exchange, London.

AN ELECTRICAL ENGINEER or ELECTRICIAN wants a SITUATION either in a Company or as an Assistant to a professor of physics. Has good testimonials.—Apply to R. W., *The Electrician* Office.

TO ELECTRIC LIGHT COMPANIES.—It is proposed to LIGHT Four of the principal Hotels in Manchester from one contiguous centre.—For information and particulars please address to FREDERICK MURGATROYD, 6, John Dalton-street, Manchester.

FOR SALE.—A NUMBER of DIRECT and ALTERNATE CURRENT DYNAMOS and ARC LAMPS, chiefly by Siemens Bros.; little used and newest types; half price.—A. MACKAY, 104, Commercial-street, Dundee.

WANTED.—Two Pairs of MICRO-TELEPHONES and RECEIVERS. Must be of good make, and in first-class working order.—Send price and full particulars to X. Y. Z., care of Editor, this paper.

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NOTES.

Cable Interrupted.—The cable between Maranham and Para is interrupted.

Natal.—A committee has been formed at Durban to facilitate postal and telegraphic service between Natal and the Gold Fields.

Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended May 30th amounted to £3,372.

St. George Telephone Company.—Mr. Justice Chitty has appointed Mr. G. Boggis, of 14, St. Swithin's-lane, E.C., official liquidator of this company.

Book Received.—"A Handbook of Electrical Testing," by H. R. Kempe, third edition. Published by Messrs. E. and F. N. Spon, Charing Cross and New York.

Electric Lights for War Vessels.—H.M.S. "Wanderer," Commander Orford Churchill, is being fitted with the electric light prior to her departure for China.

The J. B. Rogers Electric Light Company.—Vice-Chancellor Bacon has appointed Mr. F. G. Painter, of 2, Moorgate-street-buildings, E.C., official liquidator of this company.

The Turner Gas Engine Company.—A petition for the winding up of this company was presented on the 17th ult., and will be heard before Mr. Justice Chitty on the 14th inst.

Cable Repaired.—The West India and Panama Telegraph Company announce that the Key West-Havana cable is now repaired, restoring communication, *viâ* Cuba, to all West Indian stations.

The "Great Eastern."—After all, the "Great Eastern" is not to be turned into a coal hulk. Her late purchasers having failed to complete their contract the huge vessel is again for sale or charter.

Dividend.—The directors of the Brazilian Submarine Telegraph Company have declared an interim dividend of 3s. per share, or 6 per cent. per annum, free of income-tax, for the quarter ending March 31st.

Eastern Extension Telegraph Company.—The traffic receipts of this company for the month of May, 1884, amounted to £35,910, and £32,156 for the corresponding period of 1883, being an increase of £3,754.

Earthquake in Persia.—A violent shock of earthquake occurred on the night of the 18th of May, at the Island of Kishin, near the Persian Gulf. Two hundred persons were killed and many injured. Twelve villages were destroyed.

Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending May 30th were £2,632, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

The Chicago Convention.—President Arthur has had a private wire erected between Chicago and White House, Washington, in order that he may keep himself acquainted with the doings of the Republican Convention assembled at Chicago.

The Bennett-Mackay Cable.—A despatch from the "Faraday," dated June 2nd, midnight, states that she has paid out 840 miles of cable from Dover Bay eastwards. She has buoyed the cable, says a Reuter's telegram, and will return to England.

The Soudan.—The latest news from the Soudan reports that the Governor of Dongola is repairing the telegraph wires. The inhabitants are also said to be repairing the wires near Bebbeh, but much progress could not be made, owing to lack of materials.

The Model Telpher Railway.—Professor Fleeming Jenkin's model of his telpher railway can be seen in action at No. 18, Fitzroy-street, W., on Friday afternoons, by members of the Society of Arts and others, on presentation of their visiting cards.

From Suakim.—The correspondent of a daily paper states that Osman Digna has imprisoned forty of his men, who were so scared at the electric light shown from one of Her Majesty's vessels in Suakim Harbour during a recent night attack that they incontinently bolted.

Kelway's Electric Log Syndicate.—A petition for the winding up of this company is to be heard by Mr. Justice Kay on the 13th inst. The company themselves have also decided to wind up voluntarily, and have appointed Mr. E. J. Morris, of Lombard-street, E.C., as liquidator.

Business Notice.—The title of the firm of Clegg and Shaw, insulated wire manufacturers, of the Alexandra Works, Varley-street, Oldham-road, Manchester, has been changed to that of Shaw and Connolly. The firm's representative in London is Mr. R. Applegarth, of 11, Queen Victoria-street, E.C.

Death of Captain Rego.—The death is announced as having taken place on the 22nd of last month, at the age of fifty-nine, of Captain Valentine Evaristo do Rego, for many years director of Portuguese telegraphs. He represented his country at the different telegraph congresses that have been held.

City and Guilds Institute.—In response to the appeal of H.R.H. the Prince of Wales handsome donations towards the General Fund and the Equipment Fund of the Central Institute in Exhibition-road have been promised by the leading City companies, the Fishmongers' Company alone contributing as much as £4,000. It is confidently expected that the sum required will be subscribed.

Communication with the Eddystone Lighthouse.—At the last meeting of the Plymouth Chamber of Commerce a letter was read from Mr. G. F. Rogers offering to prepare plans and estimates for laying a cable to the Eddystone, provided Lloyd's or the Chamber would lend a steam tug free of charge for the purpose. He estimated he could lay and put a cable in working order within six weeks.

South Kensington Mutual Electric Lighting Company.—On Friday week Mr. Justice Kay heard the petition of Mr. W. Burchell, the solicitor of this company, for a winding-up order, on the ground of its inability to pay his bill of costs, which he had applied for in the usual way. The company had been recently formed, but had done no business, although the memorandum of association was framed in the ordinary manner. The object of the company was to light up certain parts of South Kensington by electric lights, but they were wholly unsuccessful.—His lordship made the order applied for.

Fire in an Electric Light Factory.—About noon on Saturday last a fire broke out in the Swan United Electric Light Company's new factory in the Rue des Sarrazins, Lille, France. It commenced in the room where the lamp globes are exhausted, and quickly spread to other portions of the

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works. Luckily the workpeople had just left for *déjeuner*. The fire rapidly assumed large porportions and attacked the surrounding buildings, which were severely damaged. It was got under about 4:30 p.m. It is estimated that damage to the extent of 500,000fr. has been done. The company were insured for 800,000fr.

CHINA.—The Great Northern Telegraph Company publishes the following list of towns in China which are now connected by telegraph, with the rates per word in each case:—Hong Kong, Shanghai, Foochow, Amoy, and Gutzlaff, 8s. 4d.; Canton, Fattschan, and Ngouchow, 8s. 9d.; Chinkiangpoo, Lanchee, Shiakwan, Chinkiang, Nankin, Soochow, Chining, Ningpoo, Taku, Kiukiang, Nganken, Tientsin, Kiuning, Puching, and Wuhu, 9s. 7d.; Hankow (telegrams addressed "Hankow" are until further notice sent by daily steamer from Kiukiang), 7s. 10d.; Tungchow, 10s.; Pekin (plus postage of 1s. 10d. from Tungchow for each telegram), 10s.

AN ELECTRIC RAILWAY IN SWITZERLAND.—It is proposed to construct an electric railway between the Hotel des Alpes at Chillon and the Hotel de Mont Fleury at Montreux. The difference in altitude of these two points is about 180 metres. Preliminary experiments have already been made. An electric motor placed on the car drives a cog wheel; this wheel gears into a central cogged rail, and in this way the car is made to traverse the ascent. Conductors placed alongside the central rail convey the current from the generator, which is driven by a 5 horse-power locomotive. It is intended to drive the dynamo by water-power for the future.

THE TELEPHONE AND DYNAMITERS.—On the occasion of the recent explosions of dynamite in Scotland-yard and St. James's-square, the police authorities telephoned on the first alarm to Wellington Barracks asking that the Guards should be got under arms at once, and in a very short time an answer came back by the same agency stating that the men were ready for any emergency. If the suggestion thrown out a few months since by a well-known French electrician be adopted, and the microphone utilised at station cloak rooms to detect the ticking of the clockwork of infernal machines, the combination against dynamiters will be complete. What with the telegraph, the telephone, and the microphone, their profession, which has hitherto been by no means free from risks, should become too hazardous to be worth following, despite the "piles" of the "almighty dollar" which are said to be attached to it.

THE BRUSH AND SWAN ACCUMULATOR PATENTS.—In another column we print a decision of considerable interest relating to accumulator patents. The question in dispute was as to who first invented the "perforated or cellular plate for secondary batteries having perforations or cells extending through the plate and the active material or the material to become active packed in said perforations or cells." The litigants in the case were Brush and Swan, and the matter has been before the Examiner of Interferences in the United States Patent Office for the last three years. The result is that priority is adjudged to Swan, Brush having failed to show that he made the invention prior to the filing of Swan's application for a patent. Swan's English and American patents, we may add, belong to the Electrical Power Storage Company, of Great Winchester-street, E.C. A perusal of the case leaves the impression that the patent laws of the United States are peculiar, to say the least of it.

"H" AT OXFORD.—Mr. R. H. M. Bosanquet has determined the mean value of the horizontal component of the earth's magnetism at Oxford. In a paper in this month's *Phil. Mag.* he writes:—"In Gauss's 'Atlas des Erd Magnetismus' there is a table of the magnetic elements for points differing 10° in longitude, and 5° in latitude. Forming the differences appropriate to Oxford, taking its position to be $1\frac{1}{4}$° west and $\frac{1}{4}$° north of Greenwich, and finding the Greenwich quantities from the data in Everett's book of units, I get—

Mean Greenwich value of H for 1884	·18186
Correction deduced from Gauss's differences for Oxford	– ·00227
Value for Oxford thus obtained	·17959
Result of present determination	·18010

It appears, therefore, that the observed result is somewhat nearer the Greenwich value than the indications of Gauss's differences would lead us to suppose."

PRIVATE LIGHTING.—Mr. C. P. Huntington, of Astley Bank, Darwen, Lancashire, has adopted the electric light at his mansion at Astley Bank. An engine house has been erected by Mr. James Pilkington at the rear of the house, in which one of Crossley's gas engines has been fitted. The engine is $3\frac{1}{2}$ horse-power, and drives a Victoria B^2 compound dynamo. The lamps used are Brush 60 volt incandescents, and they are fitted on the existing gas lamps and chandeliers. Three electric lights take the place of six gas lights. The following figures show the way in which the lamps are distributed, viz.:—Drive 4, hall 4, verandahs 6, drawing room 15, dining room 4, reception room 5, billiard room 13, study 1, sitting room 4, nursery 6, house maid's pantry 1, engine house 2, bed rooms 13, landings 8. In Mr. Huntington's bedroom there is a little button, and by pressing his finger upon it he can stop the engine. The verandahs have not before been lighted, as it was believed that gas would have an injurious effect upon the plants, but the use of incandescent lamps in no way injures the vegetation, and produces a very pretty effect. The whole of the work has been successfully carried out by Mr. F. D'A. Goold, electrical engineer, of Manchester.

THE TELEPHONE AND BREAKDOWNS.—"The practical use of telephonic communication was well illustrated in Manchester on Saturday last," says the *Mechanical World* of the 5th inst. "At a large works employing several hundred hands a main shaft, 5in. in diameter, was broken by torsion at a few minutes before closing time. Had not the telephone been available a messenger despatched to the nearest engineering works would have arrived after the men had dispersed and the works had been closed. The telephone being brought into requisition, the manufacturers were enabled to communicate with a firm of engineers two miles away in time to make preparations for repairing the broken shaft, and on Monday morning everything was ready to start at the usual time. It would have been more convenient for the manufacturers to have employed engineers nearer at hand, but unfortunately none were in telephonic communication. Here at least a day's wages was saved for several hundred hands, and a day's stoppage of valuable machinery was prevented by the fact that the works were connected with the Telephonic Exchange. On the other hand, a very profitable piece of work was lost to a firm of engineers who were not so connected."

ELECTRIC LIGHTING AT PLYMOUTH.—The opening of the new promenade pier at Plymouth took place on Thursday, the 29th May, in the presence of a large company. This is the first pier in which the electric light has been used throughout The deck of the pier is lighted by eighteen Brush arc lamps enclosed in hexagonal lanterns, glazed with ribbed glass which,

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while toning down the glare, materially aids the diffusion of the light. The refreshment rooms, reading rooms, and book stall are lighted by thirty-two incandescent lamps run in groups of eight on the arc current. Two No. 6 Brush dynamos furnish the current, each machine supplying nine arc lamps and sixteen incandescent lamps. The power is supplied by a sixteen-horse Otto gas engine placed under the head of the pier. The effect on Thursday when the lamps were turned on was magnificent, the whole pier being flooded with a soft white light which illuminated a considerable portion of the Hoe, upon which thousands of people had congregated. The pier itself was crowded to its utmost capacity, over 14,000 paying for admission. The work was carried out for the Great Western Electric Light and Power Company by Mr. J. Woolley, the superintendent of their Bristol lighting station. Messrs. Callender supplied the cable, and Messrs. Verity the electroliers.

THE TURIN EXHIBITION.—Our correspondent at Turin writes:—"After long delay, occasioned by the non-arrival of the plant for the establishment of several systems of electric lighting, the electrical section of the Turin Exhibition was opened by the King and Queen of Italy on Tuesday evening, the 27th of May, at nine p.m. Their Majesties entered the magnificently illuminated gallery at the appointed hour, and after saluting the numerous members of the Royal family and the municipal authorities and executive committee there assembled, they commenced their tour round the gallery accompanied by Professor Galileo Ferraris. Their Majesties first entered the space allotted to the Eastern Telegraph Company, and examined minutely Sir William Thomson's 'recorder.' Both the King and the Queen declared themselves astonished at the admirable way in which the instrument worked, and said that they would return another day to examine it more at their leisure. As representative of the 'Eastern' Company the Chevalier Alfred Eggington informed their Majesties of the extended system of cables belonging to the company, and His Majesty highly praised the energy displayed by the company as carriers of such an immense international traffic. After the Royal party had left the building the doors were thrown open to the struggling crowd, which soon filled the vast hall, and was with difficulty persuaded to abandon the dazzling scene even at midnight. The Turin Exhibition is a decided step in advance of that of Milan. It remains now to be seen if Naples in 1886 will improve on the present one."

ELECTRIC LIGHTING AT HULL.—At a recent meeting of the lighting committee of the Hull Corporation the subject of the electric lighting contract with Messrs. Siemens was gone into. The borough engineer laid before the committee the following letter from Messrs. Siemens:—"We are quite willing to let the electric lighting plant remain at Hull on hire after the expiration of the present contract (28th July, 1884), subject to the following conditions:—1. That the plant he handed back to us at the end of the period of hiring in the same condition, fair wear and tear excepted, as it is handed over by us to the corporation at the end of the present contract, unless the plant is purchased by the corporation during or at the expiration of the period of hiring. 2. That the plant is hired for at least one year from the expiration of the present contract, and that after that time either party can give three months' notice to determine the contract. (3). That the corporation pay us a sum of £476 per year in four equal instalments, payable at the end of each three months. In case these conditions are accepted we have no objection to Mr. Melhuish accepting employment under the corporation to take charge of the plant during the period of hiring." The borough engineer expressed the opinion that the terms contained in this letter were favourable, and should be accepted. The committee having discussed the matter, resolved to endorse the borough engineer's opinion, and to recommend the general committee to accept Messrs. Siemens' terms subject to a contract to be entered into and approved by the town clerk. A further resolution was passed retaining the services of Mr. Melhuish at a salary of £250 per annum.

ELECTRIC LIGHTING ON SHIPS.—The steamship "Royal Dane," one of the fleet of steamers owned by the Tyne Steam Shipping Company, has been fitted up with the electric light, and if the new mode of illuminating turns out all that it is expected to do, all the passenger steamers of the company will be fitted up in the same manner. The current is derived from one of Siemens' dynamo machines placed in the engine room, and driven by a 4 horse-power Tangye engine, which can be supplied with the steam from either the main boilers or the donkey-engine boiler. Lights of 20 candle-power each are fixed in the saloon, sleeping berths, and other places, and portable lamps are supplied for the engine room and stoke rooms. A switchboard is placed near the dynamo machine, by means of which the lights can be turned on or out, each light being independent of the others. The machine is driven by rope gearing in groove pulleys; and a sliding foundation is provided for the machine, so that the gearing may be tightened whenever necessary. In addition to the lamps in the cabins, &c., two large portable lamps, each containing six lamps with an illuminating power equal to 50 candles, or equal to 300 candle-power per portable lamp, are provided for lighting the holds, so that the work of loading and unloading may be carried on safely at night time. There are altogether forty-three lights on board the vessel, and the fitting up has been done by Messrs. J. H. Holmes and Co., electric light engineers, Westgate-road, Newcastle. The "Royal Dane" is the first vessel trading from the Tyne which has been fitted up with the electric light.

ATMOSPHERIC ELECTRICITY. — In "The Beiblätter der Physik," Vol. VIII., p. 148, is a paper by Herr Holtz on this subject, of which the following abstract is given in this month's *Phil. Mag.*:—"The author refers to the papers on this subject by W. Siemens, in which no mention is made of him, although he had in 1877 already expressed the opinion that the electricity of storms is perhaps to be attributed to an electrical action of the sun at a distance. Incited by Siemens's memoir to further thought on the matter, he is led to the following view, which materially differs from that of Siemens. The sun, as Zöllner showed, could only act at a distance in case one of the electricities developed in it were dissipated in space. Assuming that the latter is the negative electricity, both the earth and the moon will acquire it. The earth is thereby exposed to the action of positive electricity at a distance from the sun, and the negative action from the moon. In consequence of the former, the surface of the earth must be constantly negatively electrified during the day and positively electrified on the night side. The action of the moon in reference to the side turned towards it and away from it would be similar, not opposite; so that at the time of the new moon there would be an enfeeblement, and at the time of full moon a strengthening of the inductive action. Aqueous vapour, as it forms, takes with it the electricity of the earth, and this is led to the upper regions of the air. If any horizontal layer is electrified even to the smallest extent, the atmosphere in which countless such layers are heaped up may show appreciable phenomena of tension. The greater violence of the storms in equatorial regions is due to the fact that the inductive action is here of course the strongest, and also the

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evaporation most abundant. The auroræ borealcs are to be explained by the fact that it is preferably the poles at which opposite electricities meet. The difficulty of establishing this hypothesis by experimental observation is increased by the fact that all the causes above mentioned act simultaneously, as well as by the fact that, along with this, secondary inductive actions of the already electrical masses of air come into play. Only in specially constructed buildings and by the aid of special apparatus would it be possible in the course of time to decide this question. The author proposes, therefore, to arrange electrical observatories (that is, special institutions for observing the electricity of storms), which at the same time would lead to a solution of the important astronomical question of the sun's electrical action at a distance."

The Western Electric Company.—The foundation and starting point of this, now one of the largest electrical apparatus manufacturing companies in the United States, or indeed the world, was a small telegraph shop in Cleveland, U.S., and its founders Mr. Enos M. Barton and Professor Elisha Gray. Its career commenced somewhat prior to 1870. In this year, however, these two gentlemen removed their business to Chicago, and in 1872 the Western Electric Manufacturing Company was organised by the consolidation of the above business with that of the Ottawa shop of the Western Union Telegraph Company. The company's first president was General Anson Stager. Since then it has absorbed several other businesses, viz., in 1875, that of George H. Bliss and Company, and that of the Electrical Improvement Company, of Galesburg, Illinois; in 1879 it took over the shop and business of the Western Union Factory in New York; in 1882, that of the Chicago Telegraph Supply Company; that of the Gilliland Electrical Manufacturing Company, of Indianapolis; and that of Charles Williams, jun., of Boston; and at this time the company's name was shortened to that at the head of this note. In a very short time the Boston and New York Works had to be enlarged, and finally the management in Chicago had to erect a huge building near Van Buren-street to accommodate their rapidly developing business, which had outgrown the accommodation of the old premises. The present building has a floor space of over 100,000 square feet, but anticipating that this may not be enough the company have purchased sufficient ground adjoining to admit of another building of the same size being erected. The floors are lighted by 100 arc lamps, which are supplied with current by dynamos on the first floor. The machinery is driven by an engine of 500 horse-power, specially made for the company by Messrs. C. H. Brown and Co., of Fitchburg, Mass.; its driving wheel weighs 25 tons. The manufactures of the company consist of telephonic apparatus, fire alarms, electric light apparatus, telegraph materials, cables, and miscellaneous articles. The company make great quantities of what is known as the Patterson cable, after the inventor, Mr. William R. Patterson. The chief peculiarity of this cable is the method of insulation adopted. Paraffin is heated to a high temperature and then charged with gas under pressure, and thus charged is forced into the lead pipe of the cable about the core of conductors, all openings among the insulated conductors of the core and all spaces remaining between the core and pipe being thus completely filled with paraffin. In cooling, the gas expands as the paraffin shrinks, so that the filling of paraffin takes the form of a solid cake full of small bubbles of gas invisible to the naked eye. The gas thus mixed with the paraffin increases its insulating capacity greatly. It is said that the Patterson cable has an average insulation ten times that of the standard required for gutta percha cables, and is at the same time freer from induction than cables made of gutta percha or similar insulation. About 3,600 miles of conductors of this cable have been made, and it is in general use in the United States.

Electric Lights for Lighthouses.—We have from time to time referred to the experiments now being made at the South Foreland Lighthouses to test the relative capabilities of electricity, gas, and oil for lighthouse purposes. *The Times* of Thursday had a long article giving some additional information on the subject, the essence of which we now extract. The committee entrusted with the experiments consists of the following members of the Trinity House Corporation:—Captain Sydney Webb (Deputy Master of the Corporation), chairman; Captains Nisbet, Weller, Burne, and Vyvyan, Admiral Sir Leopold M'Clintock, and Mr. Inglis, the secretary to the corporation. Mr. Price Edwards, who was the secretary to the previous committee, acts in a similar capacity with regard to the present one. Sir James Douglass, the engineer to the corporation, is advising the committee on points of detail, and the photometric observations are entrusted to Mr. Harold Dixon. Mr. Vernon Harcourt, F.R.S., is watching the experiments on behalf of the Board of Trade. The Corporation of the Trinity House is acting in conjunction with the Scotch and Irish Lighthouse Boards, and the representatives of various foreign Governments are taking an active interest in the experiments. As our readers are aware, the South Foreland Lighthouses have been lighted by arc lamps since 1857, the current being supplied by four Holmes magneto machines (the E.M.F. of which does not exceed 60 volts), driven by a 10 horse-power nominal steam engine, by Hunter and English, another similar engine being kept in reserve. In connection with the present experiments three temporary wooden towers have been constructed in a line landwards, and bearing north-west from the permanent high light. These towers are marked A, B, and C, and are respectively used for the electric, the gas, and the oil light. Tower A is 245 feet from the high light, and tower B 180 feet from A, tower C being the same distance from B. The focal plane of all the towers is 15 feet below that of the electric high light, which is 380 feet above sea level. In the electric arrangements Baron de Meritens' arc lamps and magneto-electric machines are employed. At present there are two of these lamps and two of the machines in place, but another of each is to be added. The lamps are placed one above the other, or superposed, in the tower. The carbons used in them are compound—that is, they are made up of a number of small carbon rods of square section. "The carbons in use at the time of our visit," we are now quoting from *The Times*, "were 1½in. square, and were composed of 49 small square rods, but since then the new Berlin cored carbons of Messrs. Siemens have been employed. The two machines for producing the current are placed in the engine-house with the others, and, as we have stated, are driven by the same engine as the Holmes machines. Each of the De Meritens machines is arranged for working at 1-5th, 2-5ths, 3-5ths, and at full power, the estimated intensity of the light from each machine at those powers being respectively 6,000, 12,000, 18,000, and 30,000 candles. The machines can either be worked singly or coupled up. Like the Holmes machines, those of De Meritens produce a low tension current, and are found to be very reliable in operation and inexpensive in maintenance. The arrangements for illuminating tower B consist of a small gasworks erected by Mr. J. R. Wigham, of Dublin, whose burners are used in the tower, his system having been adopted for lighthouses on the Irish coast. The gas-producing apparatus consists of a small retort house fitted with two benches of three retorts, the necessary purifiers,

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and a holder capable of containing 4,500 cubic feet of gas. The gas is passed through a meter placed outside the tower to the burners within it, which are four in number. Each burner is composed of a series of concentric rings of jets, and the light can be started with a *minimum* power of 28 jets, and increased by gradations of 20 jets up to 108 jets, the full power of each burner, at which it develops 3,000 candle-power. There are four of these burners superposed, and they can be used either singly or together. In tower C oil lights are used, and these are produced by means of burners of the recognised Trinity House pattern. The burners at present in use have six concentric wicks, each burner developing 720 candle-power; but Sir James Douglass is preparing another burner of much higher power, having seven wicks, which will shortly be tried. The burners are arranged in three stages, and either a uniform, a biform, or a triform light can be exhibited as required. The burners are in duplicate on each stage, and by an ingenious arrangement the first lamp can be shunted out of position if necessary, and the second one lighted and shunted into its place without any appreciable loss of time. Such are the arrangements for producing the various lights. For testing them carefully elaborated arrangements have been made. An overland route has been laid down as a line of observation for a distance of 2½ miles from the towers in the direction of Deal, and stakes have been driven at every 100 feet. At half a mile from the towers on this route is hut No. 1 for taking photometric observations, and this is more particularly intended for fog work. At 1¼ mile we come upon hut No. 2, which is likewise fitted with photometric apparatus. At the limit of the range is a third hut, each hut being conveniently fitted up for the residence of the official in charge. Upon the occasion of our recent visit splendid lights of varying intensities were produced at night by each of the three systems under trial. The preliminary photometric observations appear to indicate that the electric light in comparison with either the gas or the oil light is as the sun is to a candle."

COLLIERIES AND LIGHTNING.—Writing in the *Colliery Guardian*, Col. Parnell says:—"I now come to another and separate class of terrestrial electrical discharges, and these are what are known as 'return strokes.' A practice originating in the last century with Lord Mahon of designating by this appellation lightning strokes whose force in an upward direction was too palpable to be gainsaid has to some extent grown up. Taking for granted (though on no ground, either of natural or of laboratory experience) that an ordinary lightning stroke was necessarily downwards, Mahon and other philosophers concluded that these undeniable upward strokes were a kind of *lusus naturæ*, to which 'return' (or 'returning') was an epithet of scientific suitability. As a rule, however, in these days text-books recognise the real nature of the class of discharge I am now referring to as being 'induced' electrical discharges, and with this explanation my researches enable me thoroughly to coincide. If in a system of two adjacent electrical condensers a plate of one condenser becomes discharged by means of explosion with a plate of the other condenser, so much of the charges on each of the two undischarged plates of the system as was due to the induction of the discharged plates respectively disappears, or returns to the complementary power or agency whence the act of induction had separated it. This action of return, or recombination, or disappearance, constitutes what is called a 'return stroke,' or 'induced discharge,' and its nature is similar to that of a powerful instantaneous electrical current. These return strokes occur, therefore, near the scenes of actual explosions; and here it may be mentioned that lightning-strokes (or thunderbolts) are not the only kind of explosions liable to occur in connection with terrestrial electricity. There is another class known as 'cloud explosions.' These are explosions between two detached clouds, which may have formed with each other an electrical condenser. Most of the lightning we see in the heavens during a thunderstorm is due to these cloud explosions; and lightning due to strokes between the clouds and the earth (or thunderbolts) is (fortunately for us) much more rare. Now 'return strokes' may be occasioned by induction from either lightning strokes proper or from cloud explosion strokes, and they are constantly manifested under particular conditions during thunderstorms. Their manifestations are chiefly of two kinds—viz., shocks to human beings (seldom to animals) and currents (to use the ordinary convenient nomenclature) on long lengths of more or less insulated metal. The former manifestations are (so far as I am aware) never caused except by lightning strokes proper, but the latter are caused by both kinds of explosion, and during the course of an ordinary thunderstorm are seldom absent from lines of telegraph wires. Much inconvenience is often thereby occasioned, but little danger is ever experienced, since by means of ingenious electro-mechanical arrangements the instruments can generally be safeguarded from the effects of these abnormal intrusive currents. But in our every day commercial practice are there no other long lines of metal equally exposed in a physical sense to the operations of these return strokes? Railway metals will at once occur to most of us. Quite so. And now is there any application of these rail or tram metals along which, unlike the case of ordinary railways, if powerful currents were to pass, conditions of practical interest (the action of powerful currents under certain circumstances being borne in remembrance) might be set up? Yes, unquestionably there is; and the subject forms the very kernel of my present communication. In the tram rails laid along the dry workings of coal mines exist, I believe, elements fraught with considerable practical interest to the colliery owner and (though in a far more intense degree) to the colliery pitman. The instances I am about to adduce will demonstrate to a certainty that these return strokes or induced currents have occurred at the rails in the workings of coal mines. For they have unmistakably manifested their presence by that fearfully dangerous exhibition of flashes, or sparks, which all electrical experience shows is an accompaniment of a powerful electrical current wherever in its passage along the metals that conduct it (and virtually cause it) slight gaps exist in these metals. The sparks and lights that have been seen in coal workings clearly prove that these small gaps do exist in the long lines of rail that permeate them, even if ocular examination should not (as I am afraid that it invariably would) testify to the same fact. Incidental to coal mines there are other metals, such as the long wire rope guides in the shafts, and the flat sheets, engines and other metals near the bottoms of these shafts; but I lay less stress on these pit metals, since I understand that no explosion of 'firedamp' could well be caused by any light or spark that might occur near the foot of a shaft; and that it is in the workings alone that any practical danger from sparks could occur. For the same reason I do not think that even if an actual lightning stroke should occur within a shaft—and so far as the underground portions of an ordinary colliery in Great Britain are concerned I cannot well conceive that such a stroke could possibly occur in the workings—any danger of explosion of firedamp need be apprehended. I have purposely placed the foregoing sentence in the conditional mood, for, so far as I am aware, no undoubted case of such a stroke within a shaft has yet taken place in any country."

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ELECTRO-CHEMISTRY.—Inorganic.

BY DR. G. GORE, F.R.S.

(CONTINUED FROM PAGE 7.)

According to Becquerel, copper and iron become tinned by immersion in contact with zinc in a dilute solution of the double chloride of tin and sodium at 160° F., but are not tinned by simple immersion alone in that liquid (*The Chemist*, Vol. V., p. 408). For coating iron with tin by immersion in a liquid in contact with zinc Roseleur recommends a solution prepared thus:—Take equal weights of stannous chloride, cream of tartar, and water. Dissolve the chloride in one-third of the cold water, warm the other portion of water and dissolve the cream of tartar in it, and mix the solutions; the mixture is clear and has an acid reaction. And a second solution, composed of six parts of crystal, or four of fused stannous chloride, and 60 of pyrophosphate of potassium or sodium, dissolved in 2,000 parts of distilled water. The size of the zinc should be about $\frac{1}{16}$ that of the iron. The deposition occupies several hours. When the solution becomes weak, equal weights of the pyrophosphate and fused chloride are added.

M. Heeren coats iron with tin by immersing it during two hours, in contact with zinc, in a solution of two parts of tartaric acid, three of stannous chloride, and three of caustic soda, and 100 of water (*Jour. Chem. Soc.*, Vol. XIII., p. 672). Stolba uses a solution of 5 to 10 parts of stannous chloride dissolved in 100 of water, and a very minute amount of cream of tartar added. The metal to be coated is wetted with the solution whilst in contact with particles of zinc spread over its surface (*Chem. News*, Vol. XXIII., p. 21). Brass and copper acquire a coating of tin if placed in contact with that metal in a boiling hot saturated solution of cream of tartar.

By means of the single cell process F. Weil coats copper with tin in a solution of a salt of tin in strong caustic potash or soda. A porous cell, containing a solution of the potash or soda, is placed in the bath, a piece of zinc immersed in it, the copper immersed in the hot tinning liquid, and the two metals connected together by a wire. The deposit is pure tin, and may be obtained of any thickness. To revive the inner liquid, precipitate the dissolved zinc from it by addition of solution of sulphide of sodium. (*Chem. News*, Vol. XIII., p. 2.)

By means of a separate current, fused stannous chloride yields tin at the cathode, whilst vapour of stannic chloride escapes at the anode (Faraday). He found by experiment that the proportion by weight of tin deposited from fused stannous chloride, and of water decomposed by the same current was as 117·16 to 18 (Watts's "Dictionary of Chemistry," Vol. II., p. 439). Iron may be coated with a beautiful white deposit of tin by making it the cathode in a solution of stannate of potash; but the solution is gradually decomposed by contact with the atmosphere, and deposits peroxide of tin.

Various solutions yield tin by this method. Roseleur's is composed of six parts of crystals of stannous chloride, and 50 of pyrophosphate of sodium, dissolved in 5,000 parts of distilled water, the two salts being dissolved in separate portions of the water, and the solutions mixed, and then stirred till clear. It requires a large anode and a strong current. For various other electrolytic mixtures containing stannous chloride and other ingredients *see* "The Art of Electro-Metallurgy," Longman's "Text Books of Science," pp. 270-272.

Anhydrous stannic chloride did not conduct a current from 8,040 cells of W. de la Rue's chloride of silver battery. (Bleekrode, *Proceedings* Roy. Soc., Vol. XXV., p. 325.)

Separation of Alloys of Copper and Tin.—Iron is said to acquire a deposit of bronze by simple immersion in a solution of 4 to 5 parts of cupric sulphate, 4 to 5 of crystallised stannous chloride, and 100 of water.

For depositing bronze by a separate current, Salzede used a solution composed of cupric chloride, stannous chloride, nitrate of ammonium, and potassic carbonate and cyanide, dissolved in water. For the same purpose Newton used one composed of the tartrates of copper, tin, and potassium.

Formation of Crystals of Tin by Electrolysis.—The crystallisation of tin is a phenomenon conspicuously striking under some conditions in a solution of stannous chloride. The crystals of tin formed upon the cathode increase so rapidly in length as to grow across the solution, and touch the positive pole in a few minutes. And if the solution and current are strong, and the cathode small, quite a mass of crystals will soon fill the liquid, and converge towards the anode. If the anode be drawn farther away in the solution the crystals follow it. The largest crystals are produced by slow action; to produce them a platinum capsule is covered with an outer coating of wax, leaving the bottom uncovered, and then set upon a plate of amalgamated zinc in a porcelain vessel. The capsule is then filled completely with a dilute and not too acid solution of stannous chloride, whilst the outer vessel is filled with water (containing one twentieth its bulk of hydrochloric acid) up to such a height that the two liquids come into mutual contact. The electric current generated reduces the salt of tin, and in a few days the crystals upon the interior of the capsule are well developed, and should be washed with water and dried quickly. (F. Stolba, *Chem. News*, Vol. XXX., p. 177).

For the electrolytic analysis of compounds of tin see *Chem. News*, Vol. XLVI., p. 106. Also Watts's "Dictionary of Chemistry," Vol. VI., p. 676, *Jour. Chem. Soc.*, Vol. XL., 1881, p. 1,081, Vol. XLII., 1882, p. 1,320.

Separation of Cadmium.—Cd. Electro-chemical equivalent $=\frac{112}{2}=56$. A dyad cation. Sodium amalgam decomposes a solution of a salt of cadmium, and forms cadmium amalgam (Böttger). From a solution of the chloride, magnesium deposits, with strong action, a mixture of cadmium and an oxychloride of the same metal (Commaille, *Chem. News*, Vol. XIV., p. 188). I have found that crystals of silicon heated with cadmic fluoride set free cadmium.

According to Raoult, gold or copper in contact with cadmium in a concentrated and boiling solution of cadmium sulphate or chloride, decomposes these salts, and quickly deposits a white, brilliant, and firmly adherent but thin film of cadmium upon the gold or copper, even when the solution is not acidulated and no hydrogen evolved. The experiment does not succeed with the nitrate. But gold in contact with iron, nickel, antimony, lead, copper, or silver, in cold or boiling acid or neutral solutions of salts of cadmium, receives no such deposit (*Chem. News*, Vol. XXVI., p. 240; Vol. XXVII., p. 59; *Jour. Chem. Soc.*, Vol. XI., p. 464).

By means of a separate current a spongy deposit of cadmium is obtained from its chloride solution to which a few drops of sulphuric acid have been added. Cadmium ammonio chloride gives a grey non-adherent deposit, chlorine being evolved. A similar deposit was obtained from cadmium calcium chloride. Cadmium bromide, acidulated with weak sulphuric acid, gives a coherent mass, susceptible of polish. If an iron wire be used as the cathode, and a copper one as the anode, the cadmium is deposited in long brilliant needles. A good result is also obtained with cadmium ammonio bromide. Cadmium ammonium iodide yields a spongy mass. The sulphate gives a coherent deposit capable of receiving a fine polish. A non-coherent deposit was obtained from the double sulphate of cadmium and ammonium (A. Bertrand, *Jour. Chem. Soc.*, 1877, Part I., p. 161). Russell and Woolrich deposited cadmium by the electrolysis of a solution composed of cadmic carbonate dissolved in aqueous potassic cyanide, with free cyanide added, and using the liquid at about 100° F. with a cadmium anode.

For the electrolytic analysis of compounds of cadmium see *Jour. Chem. Soc.*, 1877, Part I, p. 340; also F. Beilstein, Vol. XXXVI., 1879, pp. 276 and 746; Vol. XL., 1881, p. 1,081; Vol. XLII., 1882, p. 896. Watts's "Dictionary of Chemistry," Vol. VII., pp. 229 and 790 (E. J. Smith). *Chem. News*, Vol. XXXIX., p. 185; ditto (Beilstein and Jamain), Vol. XL., p. 109; Vol. XLIII. (E. Smith), p. 61; and V. Francken, Vol. XLVI., p. 106. *Jour. Chem. Soc.*, Vol. XLII., 1882, p. 1,320.

(TO BE CONTINUED.)

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ON MECHANICAL DYNAMOMETERS.

BY GISBERT KAPP.

(CONTINUED FROM PAGE 9.)

A principal aim in designing a dynamometer should always be to have the most direct connection possible between power and resistance, that is between the twisting moment transmittent and the force by which this is measured. The more simple the apparatus used for balancing these two forces against each other the less liability will there be of accidental errors being introduced into the measurements. An instrument fulfilling this condition to a remarkable degree is the energy meter invented by Professor Cyrus F. Brackett, of the College of New Jersey, Princeton, U.S. It has been designed for the express purpose of testing dynamo or magneto machines, and is therefore of considerable importance to the electrical engineer. Tests of that kind can be made with two distinct objects in view. The commercial man does not concern himself about the question how much power is wasted in journal friction, air resistance, heating of the iron parts, and so on, but merely asks for the ratio between horse-power put into the belt and electrical horse-power received at the terminals of the machine; whilst the scientist, on the other hand, being more interested in the purely electrical problem, wishes to eliminate from his experiments all those mechanical resistances which have nothing to do with the actual conversion of mechanical into electrical energy. To satisfy both requirements, Professor Brackett has made two modifications of his energy meter. The principle is the same in either, and consists in measuring the twisting moment or torque which a revolving armature traversed by a current imparts to its field-magnets or other support. The twisting moment imparted to the field-magnets multiplied with the speed of the armature is a correct measure for the mechanical energy which is being transformed into electrical energy, just as the load on a Prony brake multiplied with the speed of the pulley is a correct measure for the mechanical energy which, by the medium of friction, is being transformed into heat or used for producing abrasion of the brake blocks. That this is really the case follows also from the consideration that in all mechanical processes action and reaction must balance each other, and that the torque necessary to prevent the field-magnets from revolving must exactly equal the torque which keeps the armature spinning round. The electrical energy thus produced in exchange for the mechanical energy apparently vanishing is, however, not entirely available in the shape of current and potential. Part of it is lost in magnetic friction, producing heating of the iron in field-magnets and armature, part goes in heating the coils or sparking at the brushes and so on, leaving only a portion of the total energy available at the terminals of the machine. If we now accurately measure the mechanical energy which keeps the armature revolving, and compare with it the electrical energy derived from the terminals of the machine, we obtain the efficiency of conversion. This can be done by the aid of Professor Brackett's energy meter, shown in Figs. 31 and 32 in front and side elevation, as applied to a Weston machine. The apparatus consists of a base plate O, upon which are mounted the bearings D D, supporting the shaft of the armature, and the standards S S, supporting on knife edges K K a crossbeam, G, to which the field-magnets are bolted. In this manner the armature is carried independently from its field-magnets, and neither the friction in the journals H H, nor the friction of the brushes B B, can have any effect on them. Care is taken to bring the knife edges exactly in line with the centre of the shaft, so that the armature remains central in the bore of the pole pieces, even if the field-magnets oscillate through a small angle. A movable weight, W, placed on a graduated bar, X, serves to counteract the tendency of the field-magnets to be carried round by the movement of the armature, and another movable weight (not shown in the drawing) is used to bring the centre of gravity a small distance below the knife edges if the magnets are horizontal and the weight W stands at zero. If the machine is at work, this weight, W, must be shifted out on the graduated yard until the field-magnets are, so to speak, kept floating between the two opposing forces. The energy thus measured is exactly that which is effective in producing the current, with the exception of a very small amount due to the friction of air against the faces of the pole pieces. This, however, can experimentally be determined, and then deducted from the total measurement. No allowance whatever need be made for loss in friction at the brushes, bearings, or other parts of the machine. This is what we desire in a scientific investigation of dynamo or magneto machines; but for commercial purposes we require a dynamometer which will take all the various sources of loss into account, and such

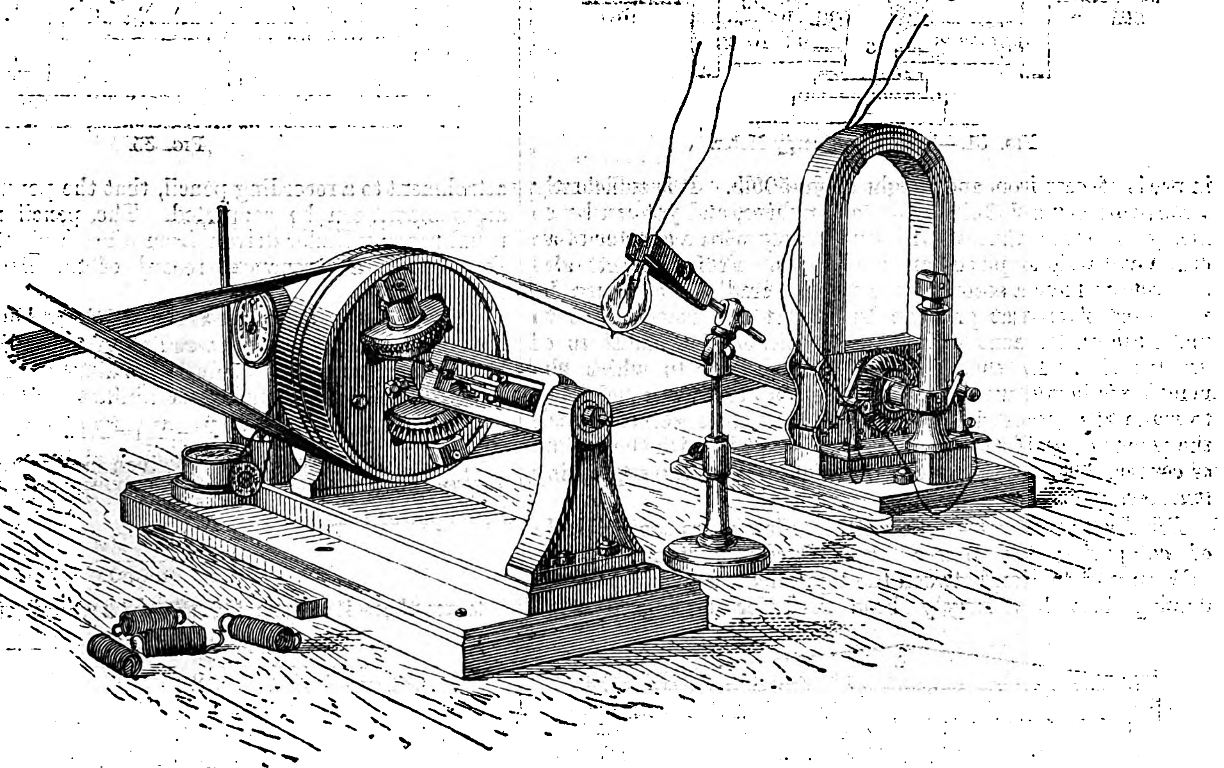

FIG. 30.—Smith's Dynamometer. A description of this machine will be found on p. 9, *ante*.

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an instrument is made by placing the machine upon a cradle, which can oscillate round centres in line with the centre of the shaft. This arrangement is shown in Fig. 33, where C C is the cradle or platform upon which is bolted the dynamo to be tested; K are frames joined to the cradle on either side of the dynamo, and provided with hardened cylindrical steel pins, as shown, which rest on steel plates supported on the beam *s*. A movable balance weight, B, serves to bring the centre of gravity within a short distance below the point of support, and the weight W indicates by its position on the steel-yard what twisting couple is required to counterbalance the torque transmitted by the belt. The author has been informed by Prof. Brackett that this device is in successful operation at the Stevens Institute in Hoboken, New Jersey. The cradle there

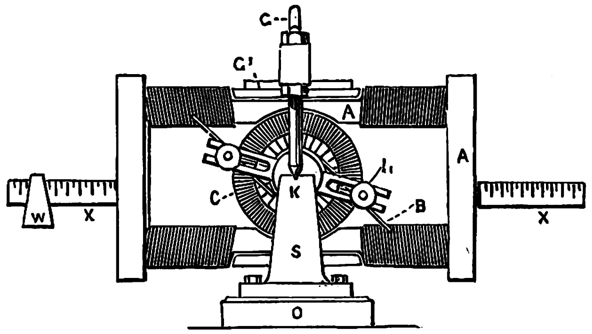

Fig. 31.—Brackett's Energy Meter.

in use is of cast iron, and weighs about 500lb. It is sufficiently strong to carry a 200-light Weston machine, and yet can be so nicely balanced that it will turn freely with a quarter of an ounce overweight placed on either side. Prof. Brackett also suggests to have a second floor to the cradle, which can be raised or lowered at pleasure by means of screws, so as to make the instrument universally applicable for machines of various size. In each case the second floor to which the machine is bolted would have to be set up to such a height as to make the geometrical axis of the armature coincide with the points of oscillation of the cradle—that is, with the points of contact between the steel trunnions and their supporting surfaces.

Belt Dynamometers.—Within the last few years the principle of computing the power transmitted by measuring the difference of tension between the tight and the slack side of a driving belt has largely been used for testing dynamo

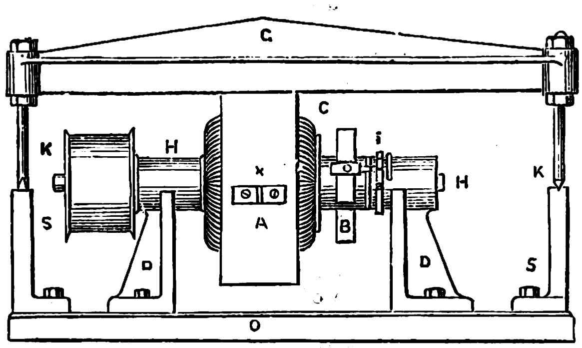

Fig. 32.—Brackett's Energy Meter.

machines. The invention of this form of transmission dynamometer is by no means new, having already been described in 1858 by the late Mr. Froude in a paper brought before the Institution of Mechanical Engineers; but its modification, due to Hefner von Alteneck, which was used in the competitive trials at the electrical exhibitions of Paris, Munich, and Vienna, is of comparatively recent date. We will describe Froude's original instrument first, and then pass on to some of its modifications. In Fig. 34 A is a pulley driven from the prime mover, and D is a pulley either mounted on the axle of the machine to be tested, or connected to it by belt or other gearing. Both these pulleys are supported by fixed bearings. B and C are two other pulleys mounted in roller bearings on either side of a lever, which is pivoted in F and stands approximately at a right angle to the centre line A D. The three pulleys, B, C, and D are equal in size, and the distance between the centres of B and C is equal to twice the diameter of these pulleys plus the double thickness of the belt, which is taken round the four pulleys, as shown in the drawing. The large pulley is about three times the diamater of the small ones, in order that the pull of the belt may be as nearly as possible vertical to the lever. It will be clear that if A be driven in the direction of the arrow, there will be a tendency of the upper part of the lever to be displaced to the left. This tendency is counteracted by a spring, P, and it is by observing the elongation of the spring, as shown by a cord-

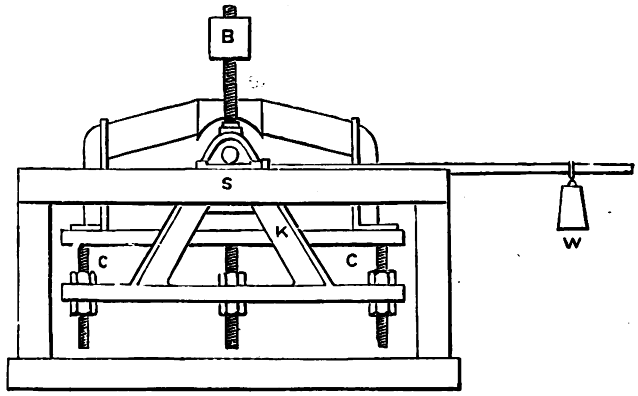

Fig. 33.

attachment to a recording pencil, that the power transmitted at any moment can be computed. The pencil moves over the usual paper cylinder driven from the shaft of pulley D, and thus leaves a permanent record of the horse-power transmitted.

Let T_1 be the tension on the driving side of the belt, T_2 that on the slack side, r the radius of the small pulleys plus half the thickness of the belt, R the distance of the spring from the fulcrum F, and P the tension in the spring; then

$$4\,r\,(T_1 - T_2) = P\,R.$$

If n be the speed of pulley D given in revolutions per minute, and P and R be given respectively in lbs. and feet, we find the horse-power transmitted

$$H.P. = \frac{\pi\,R\,P\,n}{66{,}000}.$$

Since there is a little difficulty in determining the pull of a

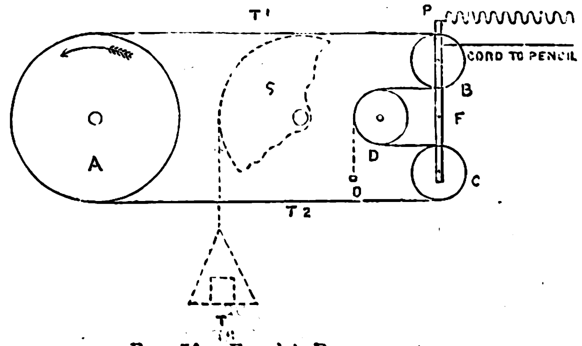

Fig. 34.—Froude's Dynamometer.

spring, Mr. Froude eliminated this quantity by a system of direct calibration, which was done in the following way:—The belt was removed, and another belt was attached to a fixed point *o*, and taken round D, B, and over a loose pulley, S, as shown in dotted lines. To the end of the belt known weights, T, were applied, and the elongation of the spring observed.

Since $2\,r\,T = P\,R$, and since also the elongation of the spring, that is the displacement of the pencil along the recording drum, is proportional to P, we can find by this experiment the scale to which the diagram is drawn. Let $P = a\,\mu$, where a is the displacement of the pencil producing the ordinates on our curve of horse-power transmitted, and μ a measure for the elastic power of the spring, then we find

$$2\,r\,T = R\,a\,\mu,$$

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and if, as is usual, $R = 2r$ (that is, the point of attachment of the spring is in line with the axis of wheel B), we have

$$\mu = \frac{T}{a}.$$

Having thus found how many pounds circumferential strain transmitted are represented by every inch displacement of the pencil from its zero position, we obtain the formula for the horse-power.

$$H.P. = \frac{\pi r a \mu n}{33{,}000}.$$

The spring used should be so proportioned that, even when transmitting a maximum of power, the lever is not pulled out too far from the vertical, or otherwise the formula becomes incorrect. Care should also be taken to have a very pliable driving band, either endless or at least so jointed as to present a smooth surface on the inside and outside.

(TO BE CONTINUED.)

ELECTRICITY AND LIGHT.—II.

BY JOHN T. SPRAGUE.

(CONTINUED FROM PAGE 8.)

11. *Energy is tranmissible in various methods.* These methods are of different orders, and may be classified in different manners. The primary distinction is that which gives the leading difference between mechanical and chemical work, *molar* and *molecular*, the action of masses of matter dependent upon pure weight, and the action of the ultimate particles of matter dependent upon the varying properties of each kind of matter. Intermediate between these, and partaking of the nature of both, is the undulatory action of fluid masses. The cricket ball gives us the simplest illustration of purely molar transmission of energy, and probably the simplest concrete view of molecular transmission may be found in a row of billiard balls in contact with each other. If another ball be caused to strike the first of such a row in the true line it comes to rest, while the most distant ball of the row takes up the motion in its place. The intermediate balls remain undisturbed; yet it is evident that each one of them has received and transmitted the energy of the motion. We know that it has done so by means of its elasticity; but if we consider each ball to represent *a molecule*, we may see that each of them must undergo a modification of structure and of properties in the act of transmission. This change is an axial one, involving a condensation and expansion, and it may be so looked at in our imagination (that is our realising or picture-forming capacity) as to enable us to conceive some definite idea of the actions which may occur in those infinitesimal molecules which are altogether beyond the reach of our observation.

12. *Polarity* is an axial difference of properties, and this successive series of condensations and expansions may be regarded either as a *linear undulation*, such as we have to deal with in the transmission of sound, or we may see in it a rough illustration of one form of polarity, and in the row of balls we may see a picture of a *polarised chain of molecules* along which energy is transmitted.

13. *Force and energy*, words which till of late years were used indifferently in the sense of power, are now clearly differentiated, so that force expresses *causes*, while energy expresses *results*, work, or work capacity. But in the usual treatment of this subject this distinction is so strongly pressed that a deeper truth is in danger of being overlooked. For *mathematical purposes* the distinction is essential, and it is permissible, therefore, to treat "force" as a real existence. For *physical purposes* it is equally important to understand that "force" is little more than an abstract symbol—that almost everything which we call a force is really an expression or action of energy. Gravitation, cohesion, and other attractive forces do really appear to have a true existence in nature—to be specific properties of matter. Nevertheless there are abundant evidences that the day may come when it will be seen that their true causes lie in a capacity of matter to absorb energy, and that they are simply a result of and an evidence of the presence of this energy.

14. *Heat, light*, and other agencies which used to be regarded as essential forces, and to explain which specific fluids were invented, are now universally admitted to be such evidences and actions of energy, and the conception of electricity is fast undergoing the same transformation. But it is in mechanics that we may find the clearest evidence that what the mathematician calls "a force" is merely a convenient expression for the powers conferred on matter by a charge of energy.

15. *Energy developing a force*, and in turn reproduced by that force, is clearly illustrated by our row of billiard balls. A force is defined as an agency which can produce or change motion, or which can set up a stress, pressure, or tension. So every mechanical action, such as that of the bat upon the cricket ball, can be expressed in terms of force, while it is evident that this force merely expresses the momentary embodiment of the energy charged at the instant upon the bat. This is what I mean by an expression which has often been objected to, that the unit of force and the unit of energy, say the dyne and the erg, are the same value. The dyne is a force capable of doing one erg of work per second, and that force of one dyne merely expresses the fact that the agency which exerts it has a supply or store of energy so connected to it as to be capable of being expended at the rate of one erg per second; it exists, not by itself, but simply as a consequence of this supply of energy. This fundamental fact is not obvious, because though the unit conditions are equal, they vary in different ratios under all other conditions, as a consequence of the system of expression and of the mode in which energy is stored. This is the essence of the long-sustained conflict of the contact and chemical theories of the galvanic battery; the imaginary *contact force* is merely the evidence of and the expression of the *energy stored in the chemical affinities*, just as an equal force may be developed by means of a corresponding supply of energy, by aid of friction, magnetism, heat, and other molecular actions.

16. *Radiant and linear propagation* afford another classification of energy, as also of various "forces" or modes of energy. A little examination may, however, show that there is little real distinction between the two modes of transmission, that they are, in fact, simple consequences of the single or dual origin of the action. *Radiant forces* are those in which energy streams from a single point. Such are heat and light. *Linear forces* are in fact *polar forces*, resulting from energy acting axially in each direction in the molecules of matter. This is the case with electricity and its allied force magnetism. A little study of the subject from this aspect will be found profitable, and it can be followed through very simple and familiar illustrations.

17. *Radiant undulatory transmission* is seen when we drop a stone into a pool of water. The stone carries a definite quantity of energy, on the same principles as the cricket ball (Sec. 4), and it may be regarded as a store of energy which on being imparted to the water develops therein a force acting from the centre (Sec. 15), the degree of such force, as an expression, depending upon the relations of the quantity of energy and the size of the pond, that is upon the conditions to which the energy can be at once transferred. Reverting to the line of billiard balls, it may be seen that if, instead of a single one terminating the row, there were two placed on a line at right angles to the row, the motion would be divided between these two; or carrying this idea back we may see that if, instead of a single row, at each stage an increased number were placed in contact, the impulse given to the single ball would be distributed over the growing number of contacts, and would finally act, though at each stage with diminished power, upon the whole of the exterior rows.

Such a series would in fact be a part of a circle, and the successive rows of balls, in each of which an act of contraction and expansion occurs, would correspond to the circular waves which would be formed in the pond around the fallen stone, and which would transmit the energy from that stone to the

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borders of the pond, thence to be reflected and distributed till, at last wholly lost as visible motion and converted into heat.

18. Replace the energy of the falling stone by some continuous action, such as the plunger of a pump alternately lifting and lowering a bulk of water, so that each action produces a wave round it, we have the analogue of any continuous source of energy, and the explanation of the mode in which that energy represents a force whence radiant energy is transmitted. The conditions correspond to those of a large metal plate heated by a flame at the centre, from whence the heat travels by conduction in a series of circles of lower and lower intensity. As precisely the same principles apply to a sphere, we have also the analogue of a centre of combustion diffusing radiant energy as heat and light, or of a musical instrument giving out sound. The special importance of this illustration is that it offers us two distinct views of the nature of radiant energy, or rather of its mode of propagation, according as it occurs in straight lines such as correspond to the ordinary idea of *a ray*, or as it proceeds in constantly enlarging spheres of correspondingly lowered intensity.

19. *Wave action*, or undulatory motion, involves the transfer of energy from particle to particle, as in the case of the balls (Sec. 11), these particles simply moving to and fro, without actual change of the average position, against a force or resistance internal or external, as contrasted with the direct motion of a mass of matter conveying energy. If a cord loosely fastened at each end is strongly jerked, the energy is propagated in wave form to the distant end, and this action will explain the origin and principle of wave transmission of energy. Let one end be held in the hand and jerked downward; then the slack of the rope is strained and a short length of it pulled out of the normal curve until the stress set up on the rope balances the energy of the jerk, and reverses the direction of the motion. The object of this illustration is to show that, even in the solid continuous rope, energy is transferred from particle to particle, just as in water or air. Each section of the flexible and loose rope acts, in fact, just as do the adjoining molecules of water pressed together by external forces. Each of these sections corresponds to the swinging pendulum, which is the element of wave action.

20. *The pendulum* being at rest is lifted, that is to say it is charged with energy—potential energy or energy of position. When allowed to fall it does no work (ignoring air and other friction), and consequently it rises to exactly the height where this *charge of energy* is equivalent to the *force of* attraction between the earth and the pendulum weight; in fact we may conceive that this force of attraction is now actually the creature of the energy which has been expended in lifting the weight, as the force of pressure in a steam engine is the creature of the energy charged on the molecules of water. This potential energy seeking to become kinetic or free draws the weight down, and so we have the regular rise and fall of balance between these two actions as long as no energy can become free, that is as long as no external work is done.

21. *The wave motion in the pool of water* is generated in the same manner. The falling stone or moving piston presses upon a particle of water, which transmits the energy to its neighbours all around, moving them in the only direction in which they are free to move; that is it raises them against the force of gravitation, and so transfers to them the original energy applied. These particles correspond to the displaced portion of the rope, and form a similar slope; but, all being free and movable upon each other, each molecule of water acts like a pendulum weight, and falls, transmitting its energy to its neighbours while pushing them aside. As long as the free rise and fall goes on without doing work (except of course in the mutual friction which ultimately absorbs the total energy, as in the actual pendulum) the undulations will continue to be maintained, the length of the waves—that is the distance between successive crests—and also the height of the waves or amplitude of undulation depending upon the quantity of energy, the mode of its application, and the material in which the undulations are generated.

THE DIAMETER OF CONDUCTORS TO PREVENT OVERHEATING IN ELECTRIC CURRENTS.*

BY PROFESSOR GEORGE FORBES.

(CONCLUDED FROM PAGE 66.)

Having stated these preliminary facts, I shall now attempt an approximate solution of our problem.

PROBLEM III.—*A sheet of copper 1 centimetre thick and of a width b, buried at a depth d, carries a current C with a rise of temperature t above the surface of the ground, the ground being t'° above the surrounding air. When the steady flow of heat has set in, find the relation between these quantities.*

The heat generated per centimetre length per second

$$= \frac{C^2 R \times \cdot 24}{b};$$

The heat radiated† $= \cdot 0003 \times b \times t'$;

and these are equal.

$$\therefore C^2 = \frac{b^2 \, t'}{800 \, R}.$$

It would not be permissible to have the surface of the ground raised more than 5° C. in summer. Let us take 10° as a maximum value for t', $\therefore C^2 = \dfrac{b^2}{80 \, R}$.

We have also the equation of conductivity. (N.B.—Conductivity of paving stones and similar materials is ·004 to ·005, according to the experiments and deductions of Peclet, Herschel, and Lebour, J. D. Forbes, Thomson and Everett, Ayrton and Perry.) $\dfrac{C^2 R \times \cdot 24}{b}$ = heat conducted $= \dfrac{K \, b \, t}{d} = \cdot 004 \times \dfrac{b \, t}{d}$.

$$\therefore C^2 = \frac{\cdot 004 \times b^2 \, t}{\cdot 24 \, R \cdot d} = \frac{b^2}{80 \, R}$$

$$\therefore \frac{\cdot 004 \, t}{\cdot 24 \, d} = \frac{1}{80} \qquad t = \cdot 75 \times d.$$

With a depth of 2 feet, or 60 centimetres, the rise of temperature from the surface of the earth to the conductor is 45° C., and the difference of temperature between the conductor and surrounding air is 55° C. We might place the conductor under the foot pavement or street close to the surface. This would diminish the value of t, but practically we are not injured by taking a depth of 2 feet, as 50° C. is a permissible rise of temperature. Up to this depth, then, we need only consider the rate at which we can get rid of heat by cooling.

We have the equation $\quad C^2 = \dfrac{b^2}{80 \, R}$

and for 50° above the temperature of the air, assumed to be 15°, we have

$$R = 2 \cdot 031 \times 10^{-6} \text{ ohm},$$

$$\therefore C = \frac{b \times 10^3}{\sqrt{162 \cdot 48}} = 25 \, b.$$

The following table is calculated on these principles:—

Underground flat conductor of copper 1 cm. thick at a depth less than 2 feet below the surface, raising temperature of conductor less than 50° C.

Width of copper conductor 1 cm. thick.	Equivalent diameter of same section.	Current to raise surface temperature 10° C.
Cm.	Cm.	Amperes.
10	3·5	250
40	7·0	1,000
90	10·5	2,250
160	14·0	4,000
360	21·0	9,000
2,800	67·5	70,000

The second column is given to show the diameter of wire which would give the same quantity of metal, merely to admit of a comparison with the aerial conductors.

It appears, then, that if c = 70,000 ampères, we must have b = 2,800 centimetres, or the strip of copper must be 28 metres

* Paper read before Society of Telegraph Engineers and Electricians.

† It is assumed that the coefficient of cooling for the ground is the same as for a ball freely suspended. It is probably less.

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wide. This gives the least weight of copper permissible (unless, indeed, we were to diminish still further the thickness), and it gives us a section = 53 centimetres square of pure copper, equivalent to a diameter of 67·5 centimetres.

I wish here to insist very positively upon the necessity of making such conductors for large currents in the form of flat sheets. Further, when we see the enormous mass of metal required, it is clearly necessary to use iron, which reduces the cost of material to about $\frac{1}{6}$. I hold this view very strongly in opposition to my friend Mr. Preece, who maintains that for electric light leads very pure copper should be used.

There is a very important application of the principles which have here been enunciated, and this is to the currents which can be carried by coils of wire when the wire is varied in thickness or the coil is varied in size. I have been sometimes simply astounded to see the waste of labour, time, and money which have been lavished on determining the proper thickness of wire with which to wind a coil without overheating for a dynamo field magnet, for regulating coils in arc lamps, &c., while the whole thing could be done by calculation. My first experiments to test the truth of the theory were undertaken two years ago. I first attacked the question as follows :—Having two coils of the same size, but rolled with wires of different diameters, so as to occupy the same volume and to have the same weight, then if the number of turns on each bobbin is considerable the length of wire is proportional to $\frac{1}{D^2}$ (D^2 being the diameter of the wire), and the cross-section is proportional to D^2, hence the resistance of each coil is proportional to $\frac{1}{D^4}$, and the heat developed in the circuit during a unit of time varies as C^2 R or $\frac{C^2}{D^4}$. But the radiating surface of the two coils is the same; whence, if the temperature be the same in both, the heat lost by radiation and convection in a given time is constant, and the heat created in unit time must be constant.

Whence $\frac{C^2}{D^4} = a^2$, where a is constant,

and $C = a\, D^2$;

i.e., to attain the same temperature with equal-sized bobbins, the current varies as the section of the wire.

To test the truth of this law I prepared two copper tubes, with flanges at each extremity, and closed at one end, and wound equal weights of two kinds of wire of different diameters. Filling one with water, and inserting a thermometer, the current was increased very slowly until a fixed temperature, sufficiently high, was steadily maintained. The tangent galvanometer was then read off. Afterwards the same temperature was attained with the other coil in the same way. The law above stated was exactly confirmed; the tangents of the angles were proportional to the squares of the diameters.

I next tested the theory in the case of the following problem: —*Two coils of similar shape have their linear dimensions in the ratio r : 1, and the thickness of wire in the same ratio; what ratio of currents is required to raise both to the same temperature?*

Let C R H be the current, resistance, and heat generated in the smaller coil, and C′ R′ H′ the corresponding quantities in the larger coil.

Then we have

$$C^2 R = a\, H, \text{ when } a \text{ is constant.}$$
$$C'^2 R' = a\, H'$$
$$R' = \frac{R}{n}.$$

Also, since the temperatures are equal, the heat radiated and convected in the two cases is in proportion to the surfaces, or as n^2 : 1, and this is equal to the heat generated, wherefore

$$H' = n^2 H,$$

or $$C'^2 R' = n^2\, C^2\, R,$$

or $$C'^2 \frac{R}{n} = n^2 C^2 R,$$

and $$C'^2 = n^3 C^2;$$

i.e., the squares of the currents are proportional to the cubes of the linear dimensions. To test this, Mr. R. Goodwin made for me the following experiments :—Coils of wire were wound upon two bobbins whose dimensions are—

Small coil—Length = 50 mm.;
Diameter of tube = 13 mm.;
Diameter of wire = 1·05 mm.;

Large coil—Length = 100 mm.;
Diameter of tube = 25·7 mm.;
Diameter of wire = 2·09 mm.

Here $n = 2$ and $n^{\frac{3}{2}} = 2{\cdot}83 = \frac{C'}{C}$ theoretically.

At the temperature of 63°C., the tangent galvanometer showed a deflection of 37° with the small coil, and at the same temperature with the large coil the deflection of 64°. The tangents of these angles are $0{\cdot}75355 \surd$ and $2{\cdot}0503 \surd$ respectively, the ratio of which is 2·72 : 1, which agrees well with the theoretical value.

It becomes an easy thing in any case to calculate the heating of a coil when we know its cooling surface and its resistance.

Let ρ = the resistance of a coil in ohms at the permissible temperature,
S = the surface exposed to the air measured in centimetres,
t = the rise in temperature,
C = the current in amperes.

$$\cdot 24\, C^2 \rho = \text{heat generated} = E\, t\, S,$$

where E is M'Farlane's constant varying from ·0002 to ·0003. The latter value may be taken. If 50° C. be the permissible rise in temperature

$$C = \sqrt{\frac{\cdot 0003 \times 50 \times S}{\cdot 24 \times \rho}} = \cdot 25 \sqrt{\frac{S}{\rho}}.$$

N.B.—It must be remembered in practice that the resistance (cold) must be increased by $\frac{1}{5}$ of its value to give ρ.

Example :—The resistance of the field-magnets of a dynamo is 1·5 ohm cold, and the surface exposed to the air is 1 metre: find the current to heat it not more than 50°C. Here S = 10,000, $\rho = 1{\cdot}8$ ohm, and $C = \cdot 25 \sqrt{\frac{10{,}000}{1{\cdot}8}} = 33{\cdot}5$ amperes. Those who are accustomed to handling dynamos will know that this is very much what we actually find, and it gives us confidence in the applications of theory.

Conclusion.

The general result of this research seems to be that we have the factors required for arriving at correct theoretical results. The general accordance of the theory with the few experimental facts which I have been able to get hold of, give a confidence in the application of these principles.

1. One of the most important results I have obtained is that the insulation of an aerial conductor is favourable, and gives us a power of using larger currents with conductors of the same size, when the diameters are not very great.

2. In small installations, the question of safety from fire or injury to insulation is not likely to crop up, but the tables here calculated will always be useful to let us know the amount of heating.

3. It is satisfactory to have a set of tables which will give us the increase of temperature with any arrangement of currents and size of wires. But these tables which I have worked out are not (except in the case of large currents) a measure of the best size of conductor for any special installation. They indicate only the safety from heating.

4. In buried conductors the mass of metal must be very great indeed, the inferior limit being set by the amount of heating of the surface of the ground which is permissible.

5. In all ordinary applications of coils of wire we can calculate the rise of temperature, experiment and theory being found to be in accordance.

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THE ELECTRICIAN.

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CONTENTS.

Notes	73
Electro-Chemistry. By Dr. G. Gore. (Continued)	78
On Mechanical Dynamometers. By Gisbert Kapp. Illus...	79
Electricity and Light.—II. By J. T. Sprague	81
Prof. Forbes on the Diameter of Conductors. Illustrated.	83
Telephone Companies' Grievances	84
Correspondence	85
New Spring for Measuring Instruments. By Profs. Ayrton and Perry. Illustrated	85
Form of Bridge for the Measurement of Very Small Resistances. By E. C. Rimington. Illustrated	89
The Lalande-Chaperon Battery. By F. de Lalande and G. Chaperon. Illustrated	90
Literature	92
Tram-Cars Worked by Accumulators in Brussels	94
Secondary Battery Patents in the States	95
Companies' Share List	96
Telegraph Traffic Receipts for May, 1884	96

VOLUME XII.

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LETTERS.—*Several letters for "*ALPHA*" and one for "*X.Y.Z.*" are at this office.*

TELEPHONE COMPANIES' GRIEVANCES.

If we are to imagine that the complaints preferred against the Postmaster-General by the Member for Carlow a fortnight ago faithfully represent the views of the telephone companies, there seems very little chance of those companies obtaining a remedy. Probably Mr. Gray treated the matter somewhat as a national grievance, and we all know to what dimensions that sort of grievance can be magnified when seen through the spectacles of an Irish patriot. It strikes us as unfortunate that the companies have been unable or unwilling to find a spokesman who would represent their case with moderation or fairness. But that is their affair; and although, as we have just remarked, their views, separately and independently, are not perhaps those with which they are credited by their exponent in Parliament, collectively they appear to be entertained more or less by many of the telephone companies; and all of them apparently give a sort of tacit countenance to the tactics of "trying it on," an art in which every Hibernian agitator is known to excel.

Setting aside Mr. Gray's violent language, and his unjustifiable charges brought against the officers of the Postal Telegraph Department as being wholly his own, what is it that the companies are striving to obtain? It is impossible to acquit them of trying it on to a considerable extent themselves for a long time past—indeed, from the very first. Their first attempt was on the whole a success. They were beaten in the Law Courts; but the head of the Post Office, unwilling to confiscate the property that had been created by the original experimenters, permitted them to go on enlarging it on terms which were certainly not very onerous. Having achieved this triumph, the companies forthwith endeavoured to set up a monopoly of their own to the exclusion of all competitors except those who joined in the game of trying it on at the outset. To have permitted this second attempt to go on unchecked would have resulted in the creation of a system which had all the faults of a State monopoly without any of its safeguards. The telephonic public would in fact have been at the mercy of one or two gigantic corporations, unless the Post Office itself had entered into competition with them, to have done which in real earnest would indeed have given just occasion for the complaint that the Post Office meant to "strangle" them. The Post Office, however, did not compete; it did the other thing—it granted licences to competing companies where good reason was shown for competition.

Profiting by the example of the parent companies, the new competitors have been trying to evade the obligation, imposed on the rest, to sell to the Postmaster-General as many of their instruments as he thought fit to purchase. To have given way on this point would have enabled any and all of the companies to avoid the obligation by asking for new licenses, and Mr. Fawcett did not give way. On the whole this experiment has not yet been more successful than the preceding one; but it has had the effect—it and Mr. Gray's eloquence—of inducing Mr. Fawcett to consider what can be done in the way of concession. It is stated that this condition imposed on the issue of fresh licences has checked the development of telephonic enterprise. If this is the case, it furnishes fresh proof that the enterprise thus checked has not been of a legitimate sort, but one which, in the general interests of the telephonic public, it is well to postpone for a while. The very essence of the monopoly, bought and paid for by the country and placed under the control of a State department, is that it shall be worked efficiently, and for this efficiency the State can have no guarantee if it grants licences for the work to be performed by outsiders without retaining any controlling influence over it. The right to compete is one which in the interests of the public it is the duty of the Postmaster-General to reserve to himself. His acceptance of a royalty on the traffic pledges him to see that it is done as well as the State would do it, and failing this, to step in and do it himself.

But, say the companies, the monopoly conferred by the Telegraph Act did not include the telephone. The Law Courts decided long ago that it did; and it is idle to raise the question again. Yet it is raised, if not directly, indirectly by the renewed complaints that the Government will not permit trunk lines to be used for experimental cheap telephony. A more direct encroachment on the functions of the telegraph could hardly be conceived, and it entirely cuts the ground from under the feet of those who used to maintain that a telephone system is not a telegraph system. This last "try on" has not succeeded, and probably never will, for the sufficient reasons, that, firstly, there is no good reason for believing that it would give satisfaction as an electrical experiment; and secondly if it would give satisfaction, the State department, which at present possesses the monopoly of the trunk lines, would work the traffic on its own account and under regulations both

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financial and administrative that shall insure efficiency on the one hand and profit on the other. To do otherwise would be to transfer the business for which the nation paid ten or twelve millions sterling to the management and for the profit of private undertakings. And that this is what the companies have been trying to accomplish is shown by the exploits of Mr. Moseley at Manchester, who under the veil of "call offices" and "club subscriptions" has been virtually inviting the non-subscribing public indiscriminately to patronise the telephone instead of the telegraph. We do not object—nobody can object—to the telephone supplementing, or even superseding, the ordinary telegraph when it can do so satisfactorily. What we do object to is the transfer of the revenue derived from such operations into private pockets, when it rightly belongs to the public purse.

CORRESPONDENCE.

INFLUENCE OF STRESS ON THE ELECTRICAL RESISTANCE OF IRON AND STEEL WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I was pleased to find from *The Electrician*, May 17, 1884, that Mr. W. H. Johnson, B.Sc., had been making some experiments on the alteration of the electrical resistance of steel and iron wires produced by excessive longitudinal traction. As Mr. Johnson had obtained for hard piano-steel results of a contrary nature to myself, who had in the case of steel only employed moderate stress, I arranged a pair of hard piano steel wires in the same way as the nickel wire used in my investigations on the "Influence of Stress and Strain on the Action of Physical Forces."* The mean diameter of the wire was ·08246 centimetre, and the total stress was carried up ot 100 kilogrammes, or nearly 2cwt. Part of this stress was permanent, and with the remainder the resistance of the wire was increased temporarily 2·68 per cent., the increase being proportional to the load, which was increased by equal amounts at a time. As the total stress was nearly sufficient to break the wire I was disappointed, inasmuch as I fully expected that the *specific* resistance of the wire would have first increased and then decreased. Instead of this I found with excessive stress, as I had some years ago found with moderate stress, that the resistance of a steel wire is increased by longitudinal traction about three and a half times as much as it is increased in length. On referring to the abstract of Mr. Johnson's paper it will be seen, however, that the value quoted by him for the elongation of the steel wire was an *impossible* one. The amount of stress used is not mentioned, but it is stated that by it a temporary elongation of *3 per cent.* was produced. Now the strongest pianoforte wire at present in use is that employed for deep-sea soundings, and it is capable of being elongated temporarily about *1·17 per cent.*, so that Mr. Johnson's wire would have to be nearly *three times* as strong as this.—Yours, &c.,

HERBERT TOMLINSON.

King's College, June 3, 1884.

TESTING LIGHTNING CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On the 30th ult. I was called in to test two lightning conductors which had been quite recently repaired and put in *thorough* order by one of the well known erectors of lightning conductors in the north of England, and as these tests go far to show the need of testing I have pleasure in giving you the results:—

First conductor R of earth	440 ohms.
Second " "	1·25 "

Both conductors had been taken up and the earth connections made good during the last month.—Yours, &c.,

OHM.

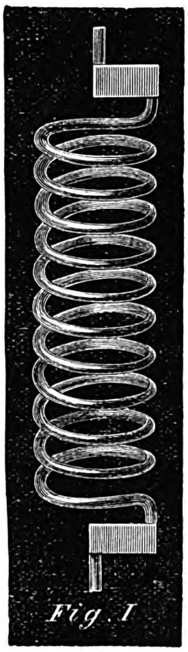
* *Phil. Trans.*, Part I., 1883, p. 58.

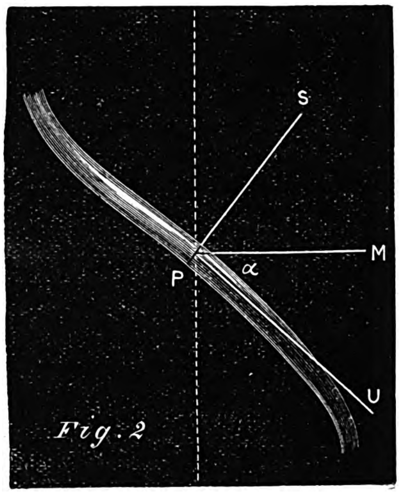
A NEW FORM OF SPRING FOR ELECTRIC AND OTHER MEASURING INSTRUMENTS.*

BY PROFESSORS W. E. AYRTON, F.R.S., AND JOHN PERRY, M.E.

In steam and gas engine indicators, the pressure of the fluid on a piston produces a slight shortening of a spiral spring which is magnified by a lever, and so the pressure of the steam or gas is recorded. In what are usually known as spring balances there is also occasionally a magnification of the elongation of a spiral spring effected by the use of a rack and pinion. Such magnifying arrangements, however, not only introduce inaccuracy by the bad fitting of hinges or of teeth, an inaccuracy which is aggravated by wear, but they increase the cost of measuring instruments and their liability to get out of order.

And, as an example of the difficulty of using a wheel and pinion for the magnifiation of an angular motion produced by a small force, we may mention that although we used this plan for a year or more in our electric measuring instruments, and although the wheels and pinions were made by a good watchmaker, still the friction involved in such a plan has induced us to abandon it in favour of the new arrangement which is the subject of this communication.





The telescopic method employed by Weber, and the spot of light method due to Sir W. Thomson for magnifying the effect of an angular motion are of course unequalled for stationary measuring instruments, but for instuments which must be carried about and used quickly without the necessity of adjustment these most ingenious reflecting methods are quite unsuitable.

With an ordinary cylindric spring, having a small angle between the osculating plane and a plane perpendicular to the axis, as is the case with all spiral springs such as are in practical use, and of which Fig. 1 is an example, it is well known that but very little rotation is produced between its ends by the application of an axial force. Consequently with such springs it is only possible to obtain magnification by the employment of a system of levers, or of a rack and pinion. It occurred to us, therefore, to consider whether it would not be possible to make a spiral spring of such a nature that for a comparatively small axial motion of its ends there should be considerable rotation of one end relatively to the other, and by the employment of which all levers, racks, and pinions could be dispensed with, so that no error could be introduced by wear and tear, or by want of fitting of joints, and further so that the temperature correction should be merely one affecting the rigidity of the material used as a spring, and not a correction such as has to be applied in consequence of the con-

* Reprinted from the *Proceedings* of the Royal Society.

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tractions and expansions of the various parts of an ordinary magnifying apparatus.

In order to ascertain this fact, it is necessary to consider what are the general laws governing the behaviour of spiral springs. Let the centres of all cross sections of the wire or strip forming the spring lie on a right circular cylinder of radius r, let the spiral have everywhere an inclination a to the plane perpendicular to the axis of the cylinder, and let a force F act at one end of the spring along the axis, the other end of the spring being fixed.

In the cross section of the wire at any point P (Fig. 2) we have, due to the axial force F, tensile stress whose effect in deforming the spring may be neglected in comparison with the other effects to be described, and we have the stresses produced by a couple, Fr, acting about the axis PM. PS, PM, and PU are all in a plane tangential to the cylinder at the point P, PM being drawn in this plane perpendicular to the axis of the cylinder, PU tangential to the spiral line, and PS perpendicular to PU.

This couple is equivalent to the couple $\mathrm{F}r\cos a$, which is a twisting couple about the axis PU, and to $\mathrm{F}r\sin a$, a bending couple about the axis PS. If now B is the flexural rigidity of the wire in the osculating plane, and if A is the torsional rigidity about the spiral line at P we have

$$\frac{\mathrm{F}r\cos a}{\mathrm{A}}$$

as ~~the angular twist per unit of length~~ about the axis PU, and

$$\frac{\mathrm{F}r\sin a}{\mathrm{B}}$$

as the angular bending per unit of length about the axis PS.

Resolving both of these horizontally and vertically, we have for the total angular motion in a vertical plane, that is, about the axis PM,

$$\mathrm{F}r\left(\frac{\cos^2 a}{\mathrm{A}}+\frac{\sin^2 a}{\mathrm{B}}\right),$$

and for the angular motion in a horizontal plane

$$\mathrm{F}r\sin a\cos a\left(\frac{1}{\mathrm{A}}-\frac{1}{\mathrm{B}}\right).$$

If the angular motion, in a horizontal plane, of the free end of the spring relatively to the fixed end be called ϕ, and if the axial increase of length be called d, and the whole length of the spring along the spiral l, then

$$\phi=l\mathrm{F}r\sin a\cos a\left(\frac{1}{\mathrm{A}}-\frac{1}{\mathrm{B}}\right) \quad . \quad . \quad . \quad . \quad (1),$$

and

$$d=l\mathrm{F}r^2\left(\frac{\cos^2 a}{\mathrm{A}}+\frac{\sin^2 a}{\mathrm{B}}\right) \quad . \quad . \quad . \quad . \quad . \quad (2).$$

The theory of the strength and stiffness of the ordinary cylindric spiral spring for small angles was given, we believe for the first time, by Professor James Thomson, in the *Cambridge and Dublin Math. Jour.*, for 1848, and in "Thomson and Tait's Natural Philosophy," Vol. I., §§ 588-608, the general behaviour of wires subjected to forces at their ends is investigated, and we might have obtained equations (1) and (2) from the general result of that investigation given in Article 607, but we have preferred to deduce these two equations from first principles.

The general expression worked out by M. de St. Venant for A for a prism of rectangular section involves an infinite series, and its use would give rise to mathematical expressions of an unwieldy character in an investigation like the present. We have therefore decided to consider our strip of which the new spring is to be made as having an elliptic section. We may mention, however, for the benefit of students, that an examination of the expression given by Thomson and Tait, "Natural Philosophy," Vol. I., for the torsional rigidity of a prism of rectangular section has led us, we believe, to detect two errors in it; one is a misprint of nab^2 for nab^3, the other that the coefficient employed $\left(\frac{2}{\pi}\right)^5\frac{b}{a}$ ought to be $\left(\frac{2}{\pi}\right)^5\frac{2b}{a}$.

A friend of ours who has been kind enough, at our request, to check the investigation agrees with us in thinking that there are two errors, but considers that the second is not in the coefficient, but in the fact that $\frac{1}{3}$ has been used in the formula in place of $\frac{1}{6}$. We still are of opinion, however, that the error is in the coefficient, because when we employ our two corrections we obtain

$$\mathrm{A}=nab^3\left[\frac{1}{3}-\left(\frac{2}{\pi}\right)^5\frac{2b}{a}\Sigma\frac{1}{(2i+1)^5}\frac{1-\epsilon^{-(2i+1)\frac{\pi a}{b}}}{1+\epsilon^{-(2i+1)\frac{\pi a}{b}}}\right]$$

where a and b are the length and breadth of the strip, and this formula, we find, agrees with the experimental results of M. de St. Venant, and also with the calculated numbers given in Thomson and Tait's "Natural Philosophy," § 709, for the torsional rigidity of a square shaft; whereas neither the formula for A given in Thomson and Tait's book nor the formula as corrected by our friend will do this.*

Reverting to the elliptic section, if the principal semi-diameters of this ellipse are b, measured in the osculating plane of the spiral, and a measured perpendicular to this plane, the values of the two rigidities are—

$$\mathrm{A}=\frac{\mathrm{N}\pi a^3b^3}{a^2+b^2}, \text{ and } \mathrm{B}=\frac{\mathrm{E}\pi ab^3}{4},$$

where N is the modulus of rigidity of the material, and E is Young's modulus.

Hence substituting, equation (1) becomes—

$$\phi=l\mathrm{F}r\sin a\cos a\,\frac{1}{\pi ab^3}\left(\frac{a^2+b^2}{\mathrm{N}a^2}-\frac{4}{\mathrm{E}}\right) \quad . \quad . \quad (3).$$

$$d=\frac{l\mathrm{F}r^2}{\pi ab^3}\left(\frac{a^2+b^2}{\mathrm{N}a^2}\cos^2 a+\frac{4}{\mathrm{E}}\sin^2 a\right) \quad . \quad . \quad (4).$$

Maximum Rotation, Positive and Negative Springs.—If we merely require that ϕ shall be a maximum for a given axial force, F, independently of the stresses produced in the material, and independently of the axial elongation, then it is evident that a ought to be equal to 45°, and l and r as great as possible. If our other condition is that the area of cross section of the strip is to be a constant,

let $\qquad ab=s,$

and $\qquad a=kb,$

so that $\qquad b^2=\frac{s}{k}.$

Then

$$\frac{1}{\pi ab^3}\left(\frac{a^2+b^2}{\mathrm{N}a^2}-\frac{4}{\mathrm{E}}\right)=\frac{1}{\pi k\frac{s^2}{k^2}}\left(\frac{k^2+1}{\mathrm{N}k^2}-\frac{4}{\mathrm{E}}\right),$$

$$=\frac{1}{\pi s^2}\left(\frac{k}{\mathrm{N}}+\frac{1}{\mathrm{N}k}-\frac{k}{\mathrm{E}}\right),$$

or since N is equal usually to about two-fifths E, we find that

$$\phi\propto\frac{5}{k}-3k.$$

Now when k is very small this is very great. On the other hand, when k is very great this is also very great, but of the opposite sign. As k increases from 0 the expression to which ϕ, or the amount of turning, is proportional diminishes until when k reaches a value nearly 13, ϕ becomes 0, or there is no rotation of the spring produced by an axial force. In fact, for small values of k there is a rotation of the spring in the direction of the coiling, and the amount of rotation becomes the greater the smaller k is, while for values of k greater than 1·3 there is a rotation of the spring opposite to the direction of the coiling, the rotation becoming greater the larger k is.

Fig. 3 shows a spring in which k is greater than 1·3, and it is found that there is an uncoiling on the application of an axial force. Fig. 4 shows a spring made of the same material, but the wire has been passed through rolls so as to flatten it in the opposite way, and now a rotation tending to coil it up is found to be produced by the application of an axial force.

* Since this paper was presented Mr. R. T. Glazebrook has been kind enough to go through the investigation, and he confirms our correction of the formula as given in Thomson and Tait's "Natural Philosophy."

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The twisting torque to which the spring is subjected is Fr cos α, and the bending torque to Fr sin α. But the twist must be multiplied by sin α, and the bend by cos α when we project these motions on a horizontal plane. So far, then, as the total rotation in a horizontal plane of the free end of the spring relatively to the fixed end is concerned, it may be regarded as being produced by equal twisting and bending torques, each of them equal to Fr sin α cos α; and the total rotation of the free end of the spring relatively to the fixed end, which is the special feature of the springs we are considering, is proportional to the difference between the two angular rotations produced in the wire by these equal bending and twisting torques. The twist alone would cause an increase in the number of coils, that is, a rotation in the direction of coiling, which is what we call positive, while the bending, or rather the unbending, alone would cause a negative rotation, or one tending to uncoil the spring. When both occur together in the actual spiral spring subjected to an axial force, the total rotation is positive or negative according as the angular twist or the angular bend is the greater. Hence the flexural and torsional rigidities of the wire alone determine whether the rotation is positive or negative.

It is well known, for example, that when a wire of circular section is subjected to equal twisting and bending torques the

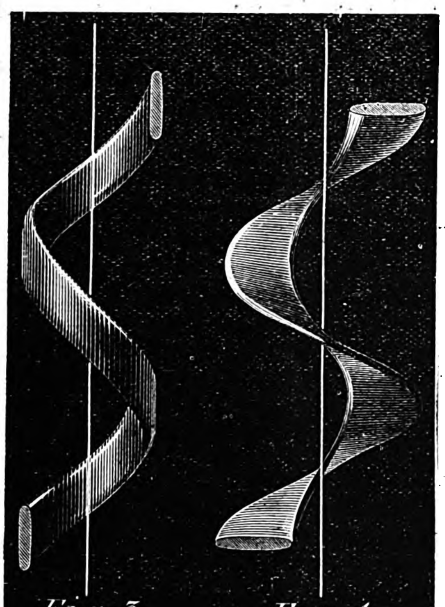

Fig. 5 *Fig. 4*

twist is greater than the bending for almost all substances, that is, substances in which the ratio of the modulus of rigidity to Young's modulus is between one-third and one-half. Hence we may expect that in a spring made of round wire, and with the spires making an angle of 45° with a plane perpendicular to the axis, the total rotation will be positive for an axial force applied so as to lengthen the spring. And experiment shows that this is the case.

If the wire be flattened and bent so that the flat side of the strip touches the cylinder on which the wire is coiled, as shown in Fig. 3, then the arrangement is such that the bending is greater than the twist. Hence an axial force applied so as to lengthen this spring causes a negative rotation, whereas if the strip be coiled as in Fig. 4, so that the edge of the strip lies against the cylinder on which it is coiled, an axial force similarly applied will now cause a positive rotation. It is almost certain that for any strip of material the positive value of ϕ obtained with the latter form of spring is likely to be greater than the corresponding negative value with the former kind, but the difficulty of manufacturing the second form of spring, where k has a very small value, has compelled us to confine our attention to the former type.

Permanent Set.—Having constructed some very delicate springs of this kind, one of the first difficulties which we met with arose from their liability to acquire a permanent set, so that it has been necessary to determine the dimensions of the spring which will give the largest amount of rotation with the minimum amount of stress in the material.

The shear stress at any point $x\,y$ in an elliptic section, if the prism has received a twist τ per unit length, is

$$N\left(\tau x + \frac{d\gamma}{dy}\right) \text{ in the direction of } y,$$

and

$$N\left(-\tau y + \frac{d\gamma}{dx}\right) \text{ in the direction of } x,$$

where

$$\gamma = -\tau\frac{a^2-b^2}{a^2+b^2}xy,$$

where a and b are the principal semi-diameters of the ellipse, the axis of y being parallel to the semi-diameter b.

Consequently these shear stresses equal

$$\frac{2b^2N\tau x}{a^2+b^2} \text{ and } -\frac{2N\tau y a^2}{a^2+b^2} \text{ respectively;}$$

and the total shear stress is equal to

$$\frac{2N\tau}{a^2+b^2}\sqrt{b^4x^2+a^4y^2}.$$

From this we see that the greatest shear stress is at the ends of the minor axis, and at the boundary is the least at the ends of the major axis.

If C is the twisting couple we know that

$$\tau = \frac{C}{A}, \text{ or}$$

$$\tau = \frac{C}{N}\frac{a^2+l^2}{\pi a^3b^3}.$$

Using these values of τ in the above we obtain for the total sheer stress at a point $x\,y$ of an elliptic section

$$\frac{2C}{\pi a^3b^3}\sqrt{b^4x^2+a^4y^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5),$$

and this at the extremity of the minor axis becomes

$$\frac{2C}{\pi a b^2}.$$

Applying (5) to our case where the twisting couple is Fr cos α, and the bending couple Fr sin α, and recollecting that the direction we have chosen for y on the section is perpendicular to the axis of the spiral, we see that at a point, $x\,y$, on the section bent about the axis of x—that is, x is perpendicular to the plane in which bending occurs—the shear stress q equals

$$\frac{2Fr\cos\alpha}{\pi a^3b^3}\sqrt{b^4x^2+a^4y^2} \quad . \quad . \quad . \quad . \quad . \quad (6),$$

and the tensile or compressive stress p at the point $x\,y$ due to bending equals

$$\frac{4y}{\pi a b^3}Fr\sin\alpha \quad . \quad . \quad . \quad . \quad . \quad . \quad (7).$$

And the resultant tensile, or compressive, stress f at the point $x\,y$ is

$$\frac{p}{2}+\sqrt{\frac{p^2}{4}+q^2},$$

therefore, since

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$$

is the equation of the ellipse, the stress at the boundary,

$$f=\frac{2Fr}{\pi a b^3}\left(y\sin\alpha+\sqrt{y^2+\cos^2\alpha\frac{b^2}{a^2}(b^2-y^2)}\right) \quad . \quad . \quad . \quad (8).$$

We have now to consider for what value of y this expression is a maximum. The possible values of y are between 0 and b; and we see that if $1-\frac{b^2}{a^2}\cos^2\alpha$ is positive, f will be greatest when y has its greatest possible value, namely b. For sections 1, 2, 3, 4, therefore, of the strip shown in Fig. 5, where AB is the axis of the spring, the greatest stress will in each case be at B. If, however, b be very large compared with a, which is

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the case in the section 5, Fig. 5, then f will not have its greatest value at B.

We find also that when

$$a < b \cos \alpha,$$

f has its greatest value when

$$y = \frac{ab^2 \sin \alpha}{\sqrt{(b^2 \cos^2 \alpha - a^2)(b^2 - a^2)}} \quad . \; . \; . \quad (9).$$

Now this value of y is greater that b so long as

$$a^2 b^2 \sin^2 \alpha > (b^2 \cos^2 \alpha - a^2)(b^2 - a^2);$$

and when these are equal we have

$$a^2 = b^2(1 \pm \sin \alpha)$$

where the positive sign is evidently inadmissible, since our condition above is a less than b.

Hence from b equal 0 through b equal a to b equal $\frac{a}{\sqrt{1 - \sin \alpha}}$, the greatest stress occurs at the extremity of the y axis. After that, the point of greatest stresss is nearer to a, but still on the circumference of the ellipse.

Now if b is very great compared with a, then we have as a limit

$$y = a \tan \alpha,$$

so that the greatest stress can never occur at the end of the semi-diameter a, but may be very near to it.

On the supposition then that, relatively to a, b has any value from 0 to $\frac{a}{\sqrt{1 - \sin \alpha}}$, the greatest stress in an elliptic section occurs at the end of the semi-diameter b, which is

amount of axial lengthening. As regards the value of α, it can easily be shown that $\frac{\phi}{d}$ will be a maximum when

$$\tan \alpha = \sqrt{\frac{E}{N} \cdot \frac{a^2 + b^2}{4a^2}}.$$

If b is small in comparison with a, which is a condition, as already explained, we are led by facility of construction to adopt, then

$$\tan \alpha = \tfrac{1}{2}\sqrt{\frac{E}{N}}.$$

As a rough approximation, taking N the modulus of rigidity at two-fifths of Young's modulus, the ratio given by M. St. Venant, this value of tan α becomes equal to $\sqrt{\cdot 625}$, or

$$\alpha = 38^\circ \; 19',$$

makes $\frac{\phi}{d}$ a maximum.

We have already seen, from (3), that to merely make ϕ a maximum for a given axial force, α ought to be 45°, and l and r as great as possible.

We are therefore led from three considerations—

1. That an axial force shall produce a maximum relative rotation;
2. That the rotation shall be great without producing permanent set in the material;
3. That the rotation shall be great in comparison with the elongation of the spring;

to make the angle of the spiral about 45°.

Further, to produce the first two of these conditions, it will be observed that the length of the wire forming the spring

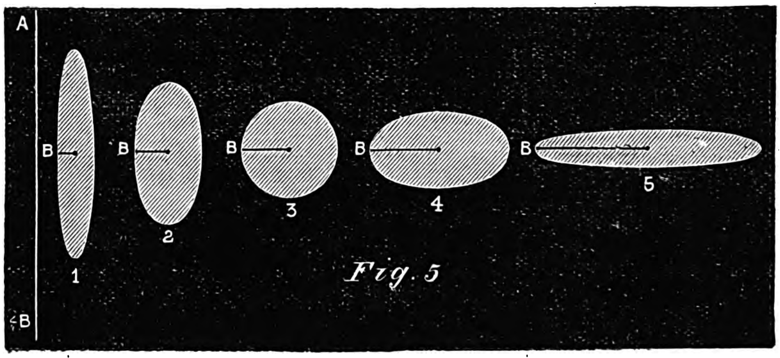

Fig. 5

parallel to the axis of y, and this is the case we will first confine ourselves to.

Maximum Rotation in Relation to Permanent Set.—If, now, f is the greatest stress at any point of the section,

$$\frac{\phi}{f} = \frac{1}{2} \frac{l}{b} \frac{\sin \alpha \cos \alpha}{1 + \sin \alpha} \left(\frac{a^2 + b^2}{Na^2} - \frac{4}{E} \right) \quad . \; . \; . \quad (10).$$

The conditions that make this a maximum are those which for a given axial force applied to our spring produce the greatest amount of turning of the free end with the least amount of stress on the material, and therefore with the least chance of permanent set. And as regards the value of α, it is clear that

$$\sin \alpha = -\tfrac{1}{2} \pm \tfrac{1}{2}\sqrt{5},$$

or

$$\alpha = 38^\circ \; 10',$$

will give the greatest value.

Maximum Rotation compared with Axial Motion.—From equations (3) and (4) we have

$$\frac{\phi}{d} = \frac{\tan \alpha}{r} \times \frac{\frac{a^2 + b^2}{Na^2} - \frac{4}{E}}{\frac{a^2 + b^2}{Na^2} + \frac{4}{E}\tan^2 \alpha} \quad . \; . \; . \quad (11),$$

and the conditions that make this a maximum are those which for a given axial force applied to the spring give the greatest amount of turning of the free end of it with the least

ought to be great, while the third condition is independent of the length.

Next, with regard to the proper radius r to give to the coils of the spring. ϕ increases with r, $\frac{\phi}{f}$ is independent of r, and $\frac{\phi}{d}$ varies inversely as r. Hence, as the first and third conditions are antagonistic one to the other, the value of r must be chosen to suit the conditions of the instrument in which the spring is to be used; that is, we must consider in any special case whether the possibility of permanent set or a large axial motion is more to be avoided in the particular instrument in question.

Let us now consider how ϕ, $\frac{\phi}{f}$, and $\frac{\phi}{d}$ depend on a and b. Referring to equation (3), if b is not greater than a, it is clear that the smaller b is the larger ϕ will be. Next putting N equal to $\frac{2}{5}$E, an approximation sufficiently accurate for the substances likely to be employed, we see from equation (10) that $\frac{\phi}{f}$ depends on

$$-\frac{1}{bE}\left(1 \cdot 5 - \frac{5b^2}{2a^2}\right),$$

and as in this first case we are limited to values of b between 0 and $\frac{a}{\sqrt{1 - \sin \alpha}}$, or between 0 and about 1·84 a if we put α equal to 45°, a value not far from that which we have already

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determined to be the best, then it is obvious that the smaller b is the larger will be $\frac{\phi}{f}$.

From equation (11) we see that $\frac{\phi}{d}$ depends on

$$\frac{(a^2+b^2)\,E - 4Na^2}{(a^2+b^2)\,E + 4Na^2};$$

or, putting N equal to $\frac{2}{5}$ E, this becomes

$$\frac{5\frac{b^2}{a^2} - 3}{5\frac{b^2}{a^2} + 13}.$$

Hence, remembering as before that b^2 has only values between 0 and $3{\cdot}4a^2$, we see that the last fraction varies between $-0{\cdot}23$ and $+0{\cdot}47$.

Hence, taking b small, which gives the greatest values for ϕ, and $\frac{\phi}{f}$, gives a value for $\frac{\phi}{d}$ not less than half as great as if we had taken the largest possible value of b.

Finally, therefore, if b varies from 0 to $\frac{a}{\sqrt{1-\sin\alpha}}$, the best practical value of b is an extremely small one, or the strip should be wound as in Fig. 3.

If b is greater than $\frac{a}{\sqrt{1-\sin\alpha}}$, conditions other than those given above may make $\frac{\phi}{f}$ and $\frac{\phi}{d}$ have their maximum values; but, since the difficulty of manufacturing metal springs of the form shown in Fig. 4 must necessarily render their employment but very limited, a mathematical examination of this problem has not much practical value. We therefore merely mention that in this case calculation shows that

$$\frac{\phi}{f} = \tfrac{1}{2} la \tan\alpha \left(\frac{a^2+b^2}{Na^2} - \frac{4}{E}\right)\frac{1}{b^2}\sqrt{\frac{b^2\cos^2\alpha - a^2}{b^2 - a^2}} \quad . \quad (12),$$

where f is the maximum stress anywhere in the section, the maximum stress in this case not occurring at the extremity of the b diameter.

The general conclusions therefore arrived at are, that in order with a given axial force to obtain a large amount of turning of the free end of the spring, combined with small maximum total stress in the material, and not too much axial motion of the free end of the spring, the strip of elliptic section should be as long and as thin as possible, should be wound in a spiral such that the osculating plane makes an angle of 40° to 45° with a plane perpendicular to the axis of the spiral, and so that the smaller diameter of the elliptic section is at right angles to the axis of the spiral.

Under these circumstances, $2a$ being the major diameter and $2b$ the minor diameter of the ellipse,

$$\phi = \frac{2lFr\sin 2\alpha}{\pi ab^3}\left(\frac{1}{4N} - \frac{1}{E}\right) \quad . \quad . \quad . \quad (13),$$

f the maximum stress at a section

$$= \frac{2Fr}{\pi ab^2}(1+\sin\alpha) \quad . \quad . \quad . \quad . \quad . \quad (14),$$

and

$$d = \frac{lFr^2}{\pi ab^3}\left(\frac{\cos^2\alpha}{N} + \frac{4\sin^2\alpha}{E}\right) \quad . \quad . \quad . \quad (15).$$

(TO BE CONTINUED.)

ERRATA.—In the article on "Tubular Carbons," published in our last issue, there are some slight errors which require correction. In the formula for the resistance of a cylindrical filament (p. 61), for

$$R = \frac{4}{\pi\delta^2} + l + a \text{ read } R = \frac{4}{\pi\delta^2} \times l \times a.$$

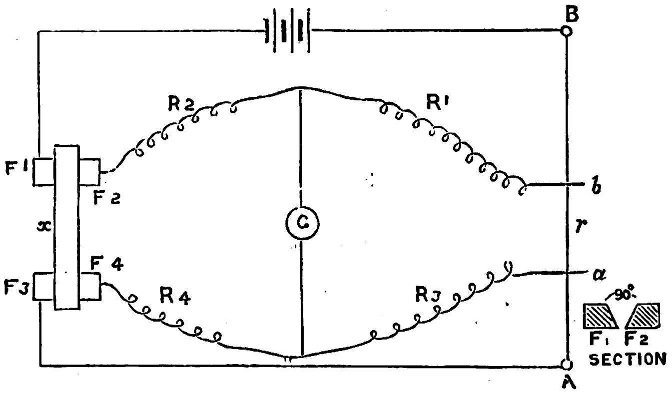
Line 16, p. 62, M. Bandsept writes, in reference to the translator's note of interrogation after the word "electrolytic action," that his meaning is perhaps better expressed by "electrolytic process," since he was speaking of a dislocating effect due to a shaking motion (ébranlement), which is more violent at the point where the current enters the carbon.

FORM OF BRIDGE FOR THE MEASUREMENT OF VERY SMALL RESISTANCES.

BY E. C. RIMINGTON.

There appeared in the *Journal* of the Society of Telegraph Engineers and of Electricians, Vol. XII., page 620, an abstract from *L'Electricien*, describing a form of bridge for the measurement of very small resistances, such as those of brass bars, carbon rods, &c.

The rod to be measured is laid upon four brass blocks $F_1F_2F_3$ and F_4, shown in section. F_1 is connected to the battery, F_2 to



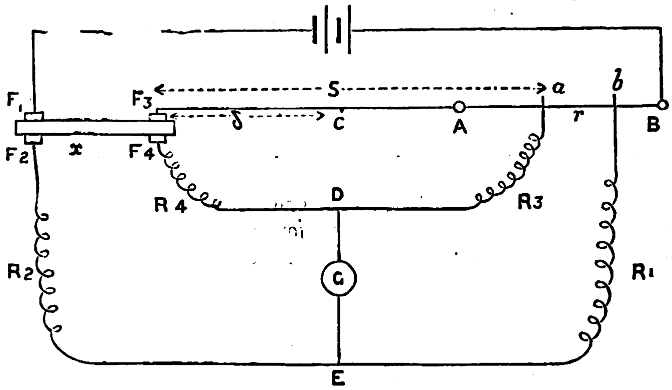
the resistance R_2, F_4 to the resistance R_4, and F_3 to A, one end of a stretched wire of German silver AB, the other end B being connected to the battery. Two contacts, a and b, attached to the resistances R_3 and R_1, slide on this wire. The resistances R_1 R_2 R_3 and R_4 remain constant, while the sliding contacts a and b are moved until there is no deflection on the galvanometer G. When this happens, according to the article, x, or the resistance of the bar between the blocks,

$$= \text{the resistance between } a \text{ and } b \times \frac{R_2}{R_1}$$
$$= \text{,, ,, ,, ,,} \times \frac{R_4}{R_3}$$

and moreover it states that the resistance measured is independent of the good or bad contact of the bar with the brass blocks.

This is decidedly incorrect, as the resistance does depend on the contact that the bar makes with the brass blocks, as I will proceed to prove.

The following diagram will perhaps show the arrangement better:—



Call the resistance of the bar x.

" " between the contacts a and b, r.

" " " a and F_3 S.

Now, when there is no current through the galvanometer there must be some point C in S such that, if we call the resistance between C and F_3 δ, $\frac{\delta}{R_4} = \frac{S-\delta}{R_3}$,

and

$$\delta = \frac{R_4 S}{R_3 + R_4};$$

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consequently the resistance betweeen C and a or $S - \delta$

$$= \frac{R_3 S}{R_3 + R_4}.$$

The points C, D, and E are all at the same potential; we can therefore suppose the points C and D joined by a thick wire of no resistance. We then have

$$\frac{R_1}{R_2} = \frac{r + \dfrac{R_3 \dfrac{R_3 S}{R_3 + R_4}}{R_3 + \dfrac{R_3 S}{R_3 + R_4}}}{x + \dfrac{R_4 \dfrac{R_4 S}{R_3 + R_4}}{R_4 + \dfrac{R_4 S}{R_3 + R_4}}}$$

$$= \frac{r + \dfrac{R_3 S}{R_3 + R_4 + S}}{x + \dfrac{R_4 S}{R_3 + R_4 + S}}$$

$$\therefore \; R_1\left(x + \frac{R_4 S}{R_3 + R_4 + S}\right) = R_2\left(r + \frac{R_3 S}{R_3 + R_4 + S}\right),$$

or $$R_1 x - R_2 r = (R_2 R_3 - R_1 R_4) \cdot \frac{S}{R_3 + R_4 + S}.$$

To eliminate the unknown resistance S we must make the coefficient of $\frac{S}{R_3 + R_4 + S}$ = zero.

$$\therefore \; R_2 R_3 = R_1 R_4$$

or $$\frac{R_1}{R_2} = \frac{R_3}{R_4} \quad \ldots\ldots \quad (A)$$

If this be so, we have

$$R_1 x - R_2 r = 0,$$

$$\frac{x}{r} = \frac{R_2}{R_1};$$

$$\therefore \; x = r \cdot \frac{R_2}{R_1}.$$

We must now see what effect the resistances of the contacts F_1 F_2 F_3 and F_4 have on the accuracy of the determination of x.

The resistance of F_1 evidently does not effect the result, as it simply adds to the resistance of the wire from the battery, so it is perfectly immaterial what resistance the contact F_1 is.

The resistance of F_3 also only adds to the resistance S, which we eliminated by making

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}.$$

But the resistances of the contacts F_2 and F_4 add to the resistances of R_3 and R_4.

Suppose all the resistances R_1 R_2 R_3 and R_4 are equal, *e.g.*, = R, and the resistance of $F_2 = \rho$, and of $F_4 = \rho_1$, then instead of (A) we have

$$\frac{R}{R + \rho} = \frac{R}{R + \rho_1}.$$

For this equation, then, to hold good ρ must equal ρ_1; if this be so we obtain

$$x = r \cdot \frac{R + \rho}{R}.$$

This brings in the resistance of ρ, which is indeterminate, and we cannot therefore find the true value of x.

If the resistances R_1 R_2 R_3 and R_4 are considerable, say 10 ohms or more each, and the contacts F_2 and F_4 are kept clean so that their resistances are very small compared with R_1 R_2, &c., we have

$$x = r \frac{R_2}{R_1} = r \frac{R_4}{R_3} \quad \text{approximately.}$$

THE LALANDE-CHAPERON BATTERY.

BY F. DE LALANDE AND G. CHAPERON.

To obtain a practical battery out of the various models of the oxide of copper cell, whose principle we made known in 1881, it was necessary to make an extended series of experiments,* the result of which may be of interest. Our object was to form a double voltaic element which would be constant for a long period. The conditions to be fulfilled in order that a couple may accomplish this are very difficult to attain; in the first place, the products should only be used when the circuit is closed, so that all combinations of two liquids are interdicted. It is requisite, therefore, to find a combination in which there is a depolarising solid. The metal to be attacked also should not react on the liquid in which it is immersed when the battery is not at work. Passing in review the series of metals, and the electrolytes which will attack them whose price permits of their use, we found that the limit of combinations in this case is very narrow. This limit is still further narrowed if we require a large amount of work from the chemical action between the metal and liquid with a closed circuit. Thus there remains little more than zinc in ammoniacal salts, or very well amalgamated zinc in acids which seem likely to accomplish the end in view. But ammoniacal salts will dissolve but a very small quantity of zinc before they give rise to insoluble crystals, which shield the metal from attack; and as regards amalgamated zinc it is very readily dissolved in dilute acids, the result being a loss which is prohibitive for a constant battery. Another combination answers far better to the conditions imposed. This is zinc and a concentrated alkaline solution. Described at different times in special treatises it had been brought to the notice of specialists at the time when we began our experiments by various articles, and amongst others those describing the Reynier battery. Potash or caustic soda mixed with water in the proportion of about 30 to 35 per cent., for instance, possesses the remarkable property of not attacking zinc in an open circuit (nor, indeed, tin, lead, and other metals), has a very small electrical resistance, and, finally, has the power, when the battery is at work, of dissolving as rapidly as acids considerable quantities of metal without giving rise to any crystallisation or deleterious deposit. It was to be hoped, therefore, that by combining zinc and an alkaline solution with an efficient depolarising solid, we could fulfil the necessary conditions for a cell which should remain mounted for a long period, like the Leclanché, whilst furnishing a constant and large current, several amperes for instance, though but of small dimensions.

Following out this train of thought, the trial of metallic oxides as depolarising material, a large number of which are insoluble in alkalies, was naturally indicated. Among all those examined by us, none seemed to supply electrodes of such capacity as oxide of copper. Peroxide of manganese, one of the first used by us, gives a high E.M.F. with an open circuit, but in alkali elements, as also in sal-ammoniac elements, polarisation ensues very quickly for a duty of some importance. We did not think it worth while to follow up the examination of this combination subsequently discovered and extolled by M. Leuchs. The various oxides of iron, natural or artificial, turned out badly, and were not reduced in any appreciable manner in the battery. However, the small layer of oxide formed by oxidation through heat on plates of iron placed at the positive pole was reduced rapidly enough, and made good contact with depolarisers, even solids. This quality of making with the positive electrode sufficiently good contact to allow the battery to work well, to make good contact, is very variable, not only with the nature of the oxides, but also with their physical state. Thus oxide of copper formed by roasting copper in the air is generally found to be in good condition for use, whilst the oxide which is chemically precipitated makes far inferior contact with the electrode. The bioxide of mercury, which it would appear should show properties very much resembling those of oxide of copper, depolarises slowly and badly, whether it is used with a support of copper,

* The authors acknowledge the services rendered to them by Dr. A. D'Arsonval in carrying out these experiments.

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iron, carbon, or even mercury. Oxides of the precious metals (silver, platinum, gold) give high electromotive forces and depolarise regularly. Oxide of silver has given, in M. D'Arsonval's hands, an E.M.F. of more than 1½ volt. Unhappily the price and the high molecular weight of silver render its use very limited. The battery thus formed is not completely reversible; the silver reduced to oxide in the working of the battery only absorbs electrolytic oxygen in an incomplete manner, whilst with copper the absorption is complete up to perfect oxidation. The same electromotive forces are obtained in fact by the use of the oxide or chloride; the latter, having a heat of formation far higher than that of the oxide, evidently will not give the same E.M.F. unless it undergoes a preliminary transformation. High electromotive forces might be hoped for with the higher oxides of nickel and cobalt obtained by an electrical recharging of elements working as secondary batteries, but these products make bad contact with the supports. Oxide of bismuth, on the contrary, which is formed by using the lower nitrate, might answer readily, but it is very inferior to oxide of copper. Bioxide of lead cannot be used.

Having ascertained in a general manner that the combination of the properties of oxide of copper and those of alkaline solutions enabled us to construct a cell which would last and give a high duty, it remained for us to design simple forms for different uses. The use of agglomerate depolarising solids in these days has been much upheld, and we tried at first to obtain oxide of copper in this form. We have obtained products having energetic depolarising properties, and offering great resistance to the dissolving action of caustic alkalies. They are prepared by mixing a small quantity of oxychloride of magnesium with oxide of copper, and moulding the material on a metal support to ensure contact. This method of using the oxide readily permits of the formation of elements of small volume and large surface. It is necessary to remark, however, that under ordinary conditions, when the battery must not be recharged after running down, these agglomerate plates become, as in the Leclanché cell, a useless residue, and the work expended in their manufacture is entirely thrown away. On the other hand, the pure metallic copper obtained by the reduction of the unmixed oxide is far from being valueless. Accordingly it seemed to us more practical to apply the oxide to the conducting support, which in this case should be horizontal by its own weight alone. We have already described different models constructed under these conditions in which the depolarising material rests on a plate, or better still, at the bottom of a metal jar. This is, in point of fact, the most handy form for numerous purposes. The use of agglomerate plates should be reserved for special cases.

In these cells the zinc is placed in the upper part, and when in work the very dense solution of zincate of potash which is formed falls to the bottom of the jar, where it lies in a syrupy layer, so that to the very end the zinc is in contact with the dilute alkaline liquid which should attack it. This it does under these conditions with perfect regularity, whilst plates of zinc immersed as far as the bottom of batteries of the same kind are eaten away with increasing rapidity from bottom to top. A plate of zinc 3 millimetres thick, placed horizontally, can be eaten away so regularly as to have at last a uniform thickness of only two to three tenths of a millimetre. In batteries at rest the separation of the solution of potash and the saturated solution of zincate which falls to the bottom may be clear enough to permit of renewing the exciting liquid by siphoning off the saturated parts to replace them. Soda gives apparently the same results as potash, both as regards E.M.F. and internal resistance. We usually employ potash, as we have already pointed out, to avoid the formation of creeping salts. This inconvenience can, however, be avoided in large cells by simply covering the surface with a liquid not attackable by soda. It is useful to employ sufficiently concentrated solutions, up to 30 or 40 per cent. for instance. In point of fact a solution containing five or six per cent. of potash dissolves but very little oxide of zinc; and a solution of alkaline zincate precipitates oxide of zinc when diluted with water. There is therefore a far greater relative proportion of unused alkali the more dilute the solution is. When the alkaline solution in the battery is saturated, though the circuit be closed, the zinc continues nevertheless to be attacked; but then oxide of zinc is deposited as much at the bottom of the jar as on the zinc, which it covers with a hard crust. The appearance of these deposits indicates the exhaustion of the battery. The carbonic acid of the air is absorbed by the potash of the batteries, especially if the surface is not protected by a cover or layer of liquid. This absorption, which otherwise is very slow, is only inconvenient so far as it renders useless the quantity of potash converted into the carbonate state. When the alkaline solution is saturated with oxide of zinc and remains exposed long enough to the action of the air, it causes insoluble crystals to be deposited in water which appear to be oxide or hydrate of zinc. One serious inconvenience is found in nearly all batteries intended to remain untouched for a long period; this is that the zinc, even with an open circuit, is rapidly attacked at the level of the liquid and to a small distance below the surface. It may in this way be completely cut in two, even if it be a thick plate, and the working of the cell be stopped. The use of insulating varnish or protecting bands of india rubber gets over this difficulty. If the zinc be suspended by a wire or rod of any other soluble metal, a local couple is formed which rapidly destroys the electrode at the point of attachment. In common with M. D'Arsonval we thought of using a rod or plate of brass or of amalgamated copper as a support for the zinc. Amalgamated zinc will not form a couple with amalgamated brass, even after a long period of immersion. This method we have adopted for all batteries required for any length of time. The zinc is always completely immersed and suspended by a conductor of amalgamated brass connected with a terminal.

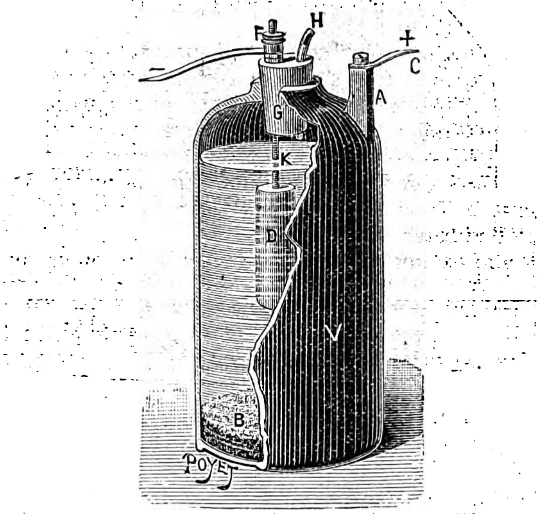

Fig. 1.—Lalande and Chaperon's Small Cell.

The oxide of copper battery can be made in many different forms, according to the service it is intended for. Besides the models already described we have designed others with an external iron jar, which offers the advantage of being hermetically closed, readily portable, and of great solidity—very important qualities for cells enclosing a caustic liquid. In one of these forms (Fig. 1) the outer jar, of ·09m. diameter, looks like a shell. It constitutes the positive pole; a terminal, A, projects as shown. The outside of the jar is paraffined when cold, so as to prevent rust and short circuiting. The zinc D is formed of a cylinder ·02m. in diameter, soldered to a rod of amalgamated brass, K, fitted in an india rubber tube, G, and carries the terminal F. The tube is also traversed by a metal tube terminated by a plug, H, formed of split india rubber tubing. These cells are usually delivered filled with the potash solution, so that to mount them it is only necessary to throw in the proper quantity of oxide of copper, which spreads over the bottom at B, and to close the cell by means of the india rubber stopper carrying the zinc. This arrangement is particularly handy for use in rooms for telephones or electric bells. This type will give a duty amounting to nearly two

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amperes. A smaller type of ·05m. diameter is fully capable of several years' electric bell work.

Fig. 2 shows another type of hermetically closed cell which has more recently been brought into use. It has a large surface, ·22m. diameter, and gives a duty of 8 to 10 amperes, which allows of its being used for the same purposes as the Bunsen and bichromate batteries, viz.:—Charging accumulators, lighting houses, electro-plating, induction coils, &c. The arrangement of this cell is very similar to that of the foregoing. The oxide of copper B is similarly spread over the bottom of the jar; the zinc D, consisting of a long plate rolled in spiral form to offer a large surface, is suspended from an ebonite cover, G, fitted on to the mouth of the jar by means of screws, as shown, and having an india rubber washer to secure the joint. These large elements have the same charge as our large trough cells, viz., two kilograms of potash and ·900 kilogram of oxide of copper, and can be used instead of them for all purposes. They are capable of a considerable amount of work. For instance, a trough battery has kept an Edison 5-candle lamp alight for more than 200 hours. By using six elements we have been able to carry on nickel-plating work during nearly two months at the rate of seven hours per day, which required three Bunsen elements. The latter required to be remounted every two days, and did not give nearly such a constant current, thus causing numerous troubles. These iron batteries have the remarkable property of being able to give without polarisation a duty far higher than corresponding

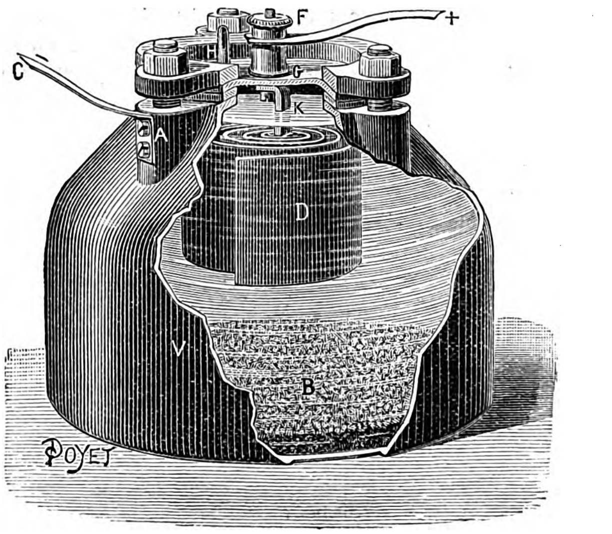

FIG. 2.—Lalande and Chaperon's Large Cell.

non-metallic cells, whose conducting surface in contact with oxide of copper should be as large. As no hydrogen is disengaged at the iron, it seems to us that its large surface must nevertheless be charged with occluded hydrogen, which is carried gradually as far as the oxide of copper, and thus assists the depolarising action in a continuous manner.

It remains for us to design some practical reversible batteries, having a large and small duty. When an oxide of copper battery is exhausted, and a suitable current is made to traverse it, the oxygen at the positive pole is wholly absorbed by the reduced copper; but if the support of the depolarising material is of copper, a small quantity of the latter is dissolved, giving a blue colour to the liquid. The copper obtained by the reduction of the oxide, however, is not dissolved. We have ascertained that by employing iron or cast iron as a support, this attacking and dissolution of the copper is avoided, provided that the oxide used has been free at the outset from metallic copper. The great difficulty lies in the deposit of zinc. This metal is precipitated in a form which is not sufficiently coherent, particularly when it is required to have moderate thicknesses. We avoid this difficulty either by precipitating the zinc on a very large surface of brass or amalgamated copper, on a mass of copper shavings for instance, or by precipitating it on a horizontal surface of amalgamated brass, covered with an excess of mercury and furnished with depressions for this metal to lodge in. The under part of this support is further covered with an insulator. The zinc can then only arrange itself on the surface, and as it immediately amalgamates the deposit becomes coherent, and can without loss furnish a fresh amount of current by its dissolution. We hope shortly to describe reversible batteries constructed in accordance with the foregoing data.

LITERATURE.

Electricity: Its Theory, Sources, and Application. By JOHN T. SPRAGUE, M.S.T.E. and E. Second edition. [E. and F. N. Spon.]

Those who know something of books will bear out the statement that originality in bookmaking is somewhat rare. The majority of books published—and especially is this the case with scientific books—follow pretty closely the lines of preceding books. Among the few original works on electrical subjects this of Mr. Sprague takes a very high position. There is hardly a page throughout his book of 650 pages which does not indicate originality of thought. A, B, or C may say this or that, but the author writes as one who, dissatisfied with blindly following mere authority, has tried the experiment for himself, and gives us the conclusions obtained under these conditions. Mr. Sprague never hesitates to say where he thinks authorities are wrong, or rather to give his reasons for thus thinking, allowing his readers to judge of the correctness of his conclusions. The present writer had the pleasure of reviewing Mr. Sprague's work in its first edition, and is gratified to see that some of the suggestions then thrown out have borne fruit. The present edition is greatly enlarged and has practically been rewritten. We can do no more than indicate its contents, making here and there comments, for to review it carefully would necessitate the writing of chapters as lengthy as some in the work itself.

In his first paragraph Mr. Sprague tells the student the directions in which his studies should tend if he hopes to learn much about electricity. He says:—"Before we can understand electricity and its various applications we require to have some knowledge of the fundamental principles of mechanics, the laws of motion, energy, force and heat; and, above all, we need some considerable acquaintance with the general principles of chemistry." We do not think Mr. Sprague is quite fair to the mathematicians. We doubt if the mathematicians have ever claimed to be the true and only exponents of the science. They rather maintain the position that being given the results of experiment they have reduced these results to mathematical analysis, and have presented the subject more in the nature of an exact science than is possible in the hands of the pure physicist. To forward the knowledge of the subject we lean towards the experimentalist, of whom Faraday stands pre-eminent. To forward the practical application we lean towards the mathematician, who, by means of his formulæ, places a weapon of attack in the hands of thousands who would not otherwise be able to contribute to progress. We contend that the pure physicist and the mathematician are coequal, the superior of either being a combination of the two. Can we give a better example of the latter than Sir W. Thomson?

Towards the end of the introductory chapter which treats of atomicity, molecular types, force, energy, &c., Mr. Sprague gives the text upon which his book sermonises:—

"According to the theory adopted in these pages, electricity is not material or a quasi-material fluid, nor is it a special force; it is a form of motion—energy charged in a special manner upon ordinary matter, and developing special relation among its molecules. Since the first edition of this work was published this view has gained much ground, and many things which were then regarded as heresies are now generally adopted as true scientific principles.

"But while scientific men are fast coming to this view of electricity, and it is very commonly employed, more particularly with dynamic electricity or galvanism, still the new theory is rarely fully set forth and substituted for the old fluid theories, and therefore it is very difficult for students to

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obtain that clear view of the subject which is desirable, especially as all the older terms of the science were devised in connection with the old theories, and are exceedingly ill-fitted to convey the new one without producing much confusion of ideas.

"This work in its original form was intended to meet this requirement, and the plan adopted has been to commence with a few leading facts and principles, then describe the various forms of instruments necessary to examine the actions of the force, and by their aid trace out the general laws and fundamental principles of the science, after which the applications of the force of which the nature has been thus examined will become far more intelligible than by piling up isolated facts, or describing mere processes however practically valuable."

In the next edition we would suggest that all reference to "Static Electricity" be omitted, except perhaps to say the "definition" is obsolete, and that all the phenomena hitherto discussed under this head can be better discussed under a subhead of dynamic electricity. The author, p. 16, now says "static electricity is, however, a misnomer, it has no existence," and he may therefore well go the other step and ignore it altogether. We are glad to find that in this edition "electrical repulsion" *is* thrown overboard. After referring to the ordinary statement in books, and, in a note, to the comment of a reviewer on the first edition, the author says, p. 22: "Hence it is stated, as a fundamental law, that bodies similarly electrified repel each other, *which is not true*, so stated;" and again, p. 57: "*Repulsion* is an indirect action of attraction. Nowhere in nature can there be found a repulsive force." We claim the credit of being first to distinctly state this heresy. Although Mr. Sprague held it when writing his first edition, he did not speak decisively on the matter. Now, however, we have it, and while an anonymous scribe like the writer may be allowed to formulate heresies and heterodoxies without attracting the slightest attention, the mere fact than an author of repute has accepted them will cause them to be closely examined and criticised. Most unhesitatingly we throw in our lot with the author. When the critics hit him we shall take shelter behind his shield. When he hits the critics we can bask in the sunshine without danger of hurt. Let us make certain, however, of how we stand. We do not agree with *all* Mr. Sprague says in this book; in fact, we do not quite grasp his idea of "energy charged in a special manner upon the molecule." We only at this point state our entire agreement with him as regards the non-existence of electrical repulsion.

The theory adopted by Mr. Sprague to explain the phenomena of the science is the "molecular theory." The molecule must be considered "as a body composed of two distinct parts linked together, but acting also as a whole from a common centre," p. 25. The two halves of the compound molecule vibrate around a central line, and a force intensifying the vibrations has the effect of breaking up the molecule giving the phenomenon of discharge. The idea of polarised molecules is explained, and the law given that "Electrical action is developed only when a complete chain of polarised molecules can be formed," p. 26. Has Mr. Sprague ever pursued the idea that the real law is just the opposite of this, which may be stated that "Electrical action is developed only when a completed chain of polarised molecules is distorted or broken?" There is another question, too, in this part of the subject which might well receive consideration. Assuming the correctness of the molecular theory, work is done in forming the chain of polarised molecules. On p. 34 we read:—"Generally it may be said that any molecule when polarised *induces* all others within its influence to follow its example, that is to say, employing the true meaning of the word, it *draws them* into the same systematic order. . . ." The molecules we presume are similar in all respects, vibrating in a sea of ether. In what way can we conceive one polarised molecule to draw or act upon a number and expend or, rather, transmit work; for it is through some action of this polarised molecule that the force necessary to polarise the chain is transmitted. At present our only conception of the action is that the ultimate molecule is not perfectly spherical, that it is restrained by the acting force in a given position, and that therefore its mean path in a given direction is altered with its axis in a given direction, and that owing to the elasticity of the ether the paths of the surrounding molecules is altered till the axes of all the molecules vibrate in parallel planes. Will Mr. Sprague help us to try and picture in our mind's eye the polarising action which he thinks goes on? It is far easier to talk about molecules being polarised than to explain how they are polarised.

One or two paragraphs at the end of the chapter on magnetism are so important for the student to grasp that we are fain to quote them:—On p. 114 our author says, "Before leaving the subject of magnetism it will be well to point out the error of the common conception of magnets as inexhaustible sources of force. It is this misconception which has led so many to waste their time in trying to devise perpetual motion machines, of which magnetism was to supply the motive power. It has also given rise to many questions as to how it is that a magnet can impart force to any number of other magnets without itself parting with any force.

"Magnets, like springs, can only exert the power which has been put into them—*they have no force of their own.* In the act of magnetising, whether by magnets or by electricity, a certain amount of energy is charged upon the molecules, just as it would if each of the molecules in Fig. 33, p. 94, were a spring, which was wound up in the act of magnetising. When the magnet exerts any force, *it parts with that force;* it is to that extent exhausted, and the energy it parts with is distributed over the new 'field,' or in the armature, &c., which has been moved. If the armature is a mass of iron as large and heavy as the magnet can hold, the magnet is exhausted, it will no longer affect external magnets, &c., or but very slightly. Before the magnet can exert any further force the requisite energy must be restored to its molecules. This is done by removing the armature, which requires an exertion of force equal to that exerted by the magnet in attracting it."

We must, however, pass on more rapidly, or we shall give no conception of what is in this work. But really Mr. Sprague is to blame for our verbosity. He says so much to make us think that we are induced at every paragraph to fly off at a tangent to the object immediately in hand. The author describes very clearly the importance of the inductive circuit, the theory of the ordinary frictional machines, the nonsense that is so often written and said about the earth connection, specially describing and illustrating, p. 41 and p. 618, the Voss and the Wimshurst induction machines, and other inductive apparatus. The whole of this (the early part of the book) should be most attentively read by the student. It contains information wholly undiscoverable, because wholly unknown to the writers, in the majority of text-books. Chapter III. treats of magnetism, and is an extension of Mr. Sprague's articles in our columns. Then comes a chapter on galvanic batteries, containing a large amount of interesting matter, but which puts us in mind of a musician who will play ten thousand times ten thousand variations on one theme. It seems to us that inventors of batteries ought to be immured in a desert island. The author does not attempt to give a list of the different batteries, which are generally variations upon a few prominent types. One of the easiest ways to obtain historic immortality is to invent a modification of some battery. There is one sentence we should like to add to this chapter, and we are sure it is an oversight of Mr. Sprague's that it is not in, for he is more than just, he is generous in mentioning the names and giving honour to the workers in the science. Is it not a fact that Sturgeon suggested the amalgamation of plates in batteries, and is not this suggestion one of the most important in the annals of electricity? Sturgeon's name is too little known to the English student; his claims to renown have been systematically overlooked, while many a lesser light is held in esteem. Alas, poor Sturgeon!

There is hardly a question about batteries that will not be solved by reference to this chapter, and we are sure that even those who think they know all about batteries will find something new herein. A very complete discussion of secondary batteries concludes the chapter, and upon the whole the author's conclusions are not very favourable to such batteries.

The remarks as to confusion about poles and plates (p. 174)

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are very pertinent, but the confusion is simply of a piece throughout the whole subject, both notation and nomenclature being sadly in want of straightening out. We imagine that many readers will look upon the diagram (p. 175) as a species of conundrum. The idea may be admirable, but it is not clearly carried out, and without the letterpress would be unintelligible. Makers of secondary batteries will do well to notice the remarks made in this part of the work, such for example as the space that must be allowed for the dilute acid, a given weight of lead requiring a given weight of acid for its conversion. This acid occupies a certain area, so that it would be wrong to attempt to pack too much lead into a given space. The proportions should be retained, giving indeed a little too much acid rather than too small a quantity. We have already said that Mr. Sprague's conclusions are unfavourable to such batteries. His words are :—"It is almost certain that, on the average, the use of storage batteries means the loss of 50 per cent. of the energy, as compared with direct working. This means doubling the cost irrespective of the value and expense of the battery itself; it is as though only one half of the gas put into a gasholder could be delivered from it, and this is why secondary batteries have come into little use, notwithstanding all that was hoped from them." This view differs from the view we hold, which is that hitherto the secondary batteries in the market have not been altogether trustworthy; the plates have buckled, short-circuited, disintegrated, and played other pranks, which experience and care in the manufacture is only now overcoming. In some cases, indeed, no fault has been found; on the contrary, the highest praise is accorded, and, after all, this experience of use is the only one which will be considered. There is much in the next few chapters we should like to specialise, but must pass on. These chapters deal with Measurement, Current, Conductivity and Resistance, Electromotive Force, Electrolysis, Electro-metallurgy, and Terrestrial Electricity, bringing us to Chapter XII., treating of Electro-Magnetism. It hardly need be said that the chapters so summarily passed over contain a vast amount of as important information as any in the work.

The latter part of the book deals with the applications of electricity which have been so rapidly developed during the past few years, such as electric lighting and telephony. Here we find discussed the principles upon which dynamo machines are built, and arc and incandescent lamps manufactured. Here, too, are discussed principles upon which the success and the economy of such lighting are founded, and some very remarkable details and tables relating to cost are given. The conclusion of the author (p. 582) is that electricity will not supersede gas, except in certain favoured localities and under certain favourable conditions.

The work concludes with a dictionary of terms and a good index.

We have been compelled considerably to shorten our notice of this work owing to exigencies of space and time, but we hope we have sufficiently indicated that in our opinion it is a work absolutely necessary for every student of electricity. There is no other book of the kind with which to compare it. Just as Clerk-Maxwell's book stands alone, so must this. The ordinary school book cannot be classed with either; and therefore, when we speak of Mr. Sprague's book standing alone, we do not intend to speak slightingly of some of the excellent books issued for school purposes. His book is not written from such a standpoint, and would not be altogether suited for school work, although it ought to be supplementary thereto. The tenets held by Mr. Sprague are undoubtedly gaining ground, and therefore demand the closest attention from every student desirous of becoming acquainted with the tendency of scientific thought.

The mere mention of the fact that the work is published by Messrs. Spon will be a guarantee that the printing and mechanical get-up of the book is well done.

Numbers of "The Electrician" Out of Print.—Vol. I., Nos. 3, 9, and 19; Vol. VII., 1, 4, 6, 8, 10, 12 to 18, 20, 21, 24, 25, 26; Vol. VIII., 1, 3, 6 to 26; Vol. IX., 2, 3, 4, 9, 17, 19, 24 to 26; Vol. X., 2, 13, 16, 19, 26; Vol. XI., 18; Vol. XII., 3, 8, and 10.

TRAM-CARS WORKED BY ACCUMULATORS IN BRUSSELS.

The Compagnie Belge et Hollandaise d'Electricité, that lighted the Venloo Station, Holland, with thirty-two 2,000-candle Brush and seventy Swan lamps, and will shortly light the Grand' Place, Brussels, has for some time been experimenting with the application of Faure accumulators to tramway traction. The manager, M. Julien, and the secretary, M. Allard, consider that they have solved the problem by employing electromotive force and quantity, according to requirements, which they effect by coupling together several batteries of elements in series or in parallels at pleasure.

The accumulators measure 17½ by 12 centimetres, or 6¾ by 4¾in. The positive plate, 4 millimetres thick and weighing 739 grammes = 26oz., has the interstices filled with red lead; and the negative, 3 millimetres thick, and weighing 568 grammes = 20oz., has the interstices filled with litharge. The weight of lead is 1,234½ kilogrammes = 24cwt. The dynamo, a Siemens D2, is placed under the floor of the car, at right angles to its central line, the car, which carries 40 passengers, weighing as fitted about five tons. The 108 accumulators, placed under the seats from the outside (though they can be charged without removal), may be grouped in series of 40, 54, 66, 80, 95, or 108, by merely shifting a lever on a toothed sector, like the reversing arrangement of a locomotive. A new switch has been devised by M. Allard, in which—supposing the number of secondary batteries to be four, of 27 elements each—all four can be coupled in series, or two in series of 54 each and two in parallel, or three in series and one in parallel, or all four in parallel. The brushes are reversed or taken off by another lever, also working on a sector, but horizontally; and reversing would be sufficient to stop the car on a heavy gradient if the brake should fail. Motion is communicated by belt from a pulley on the dynamo shaft to another on a transmission shaft, a spocket wheel on which engages with an endless chain that turns one of the axles. There are means for tightening up both the belt and the chain; and the axle revolves once for every ten of the dynamo. The car is under perfect control, can be worked forwards or backwards—as little as 10 centimetres or four inches at a time, if required—and may be driven from either end. Only one set of levers is used, however, to prevent the possibility of the wires being made red hot through both ends being worked at once; but when properly worked there is no resistance. An Ayrton and Perry voltameter, in a shunt circuit from the poles of the dynamo, permits of the electromotive force being measured at any moment; there is also an ampereometer by the same makers. The car is provided, in addition, with four incandescence lamps, two inside and two outside, supplied from the accumulators.

The experimental tram-car, which was first tried on the level portions of the Brussels tramway system, mounted one after the other the very steep gradients, combined in some cases with sharp curves. It was at length considered a great feat to ascend from the Gare du Midi, by the Porte de Hal, to the Porte de Namur, which included a gradient of 1 in 26 combined with a curve of 150 metres, or 7½ chains radius, and followed by another gradient of 1 in 21, partly on the straight and partly on a curve of 315 metres = 17½ chains radius. It was considered a still greater feat to come to a standstill on the combined curve and gradient, and then start again; but there yet remained the gradient of 1 in 16 in the Boulevard Botanique to surmount. One day M. Petit, the works manager who made the first accumulator under M. Faure's directions, was so confident of success that he wrote to the general manager that he was going to attempt it, and fearing that his intention might be frustrated, he started out at 4 o'clock the next morning before he could receive a reply. The ascent was made without difficulty; and afterwards, in the presence of the tramway officials, not only was it repeated, but the car was stopped and started again four times on the gradient of 1 in 16. This was deemed a conclusive proof of success from a technical point of view; and to show their confidence of commercial success, the directors of the electric company proposed to work a couple of branches, each

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about a mile long, for a period of six months, in return for the amount that would otherwise be expended in horse traction. The agreement was signed one day last month, and will come into operation on 1st July for the Rue de la Loi, and shortly afterwards for the Rue Beliard. Instead of transforming the cars, the company will construct a few trucks and fit them with accumulators and dynamos to draw one or two cars after them, the trucks themselves serving to carry small parcels or a few passengers. Indeed the electric company's engineers are sanguine enough to believe that the goods or passengers carried by the trucks will pay expenses, while the cars make the profit. Without presenting any very great difficulties, or a gradient heavier than 1 in 30, the two lines arranged for trial on the scale of actual working are sufficiently uneven to thoroughly test the system. It may be hoped that the commercial success will be on a par with the technical success already achieved.

J. W. P.

SECONDARY BATTERY PATENTS IN THE STATES.

The following is the decision of the Examiner of Patents in the action and claim for priority to the cellular plate for secondary batteries by Swan and Brush. We give the report exactly as it has reached us from America :—

The invention in controversy is as follows :

"A perforated or cellular plate for secondary batteries having perforations or cells extending through the plate and the active material or the material to become active packed in said perforations or cells substantially as described."

In June, 1881, Brush filed a series of applications for improvements in secondary batteries including the case I in interference. This application relates primarily to electrodes, or plates having an active coating of metallic lead mechanically applied. The drawing, as originally filed, showed several forms of plates, treated in this manner, including a flat sheet of lead with a coating of active material pressed thereon and secured in place by a sheet of cardboard, felt, or other equivalent substance ; also a corrugated plate and a ribbed plate with the corrugations or depressions filled with spongy material and mechanically pressed in place.

These plain, corrugated, and ribbed plates were the only examples of the application of the invention shown and described in the specification and drawings, and the claims as originally filed appear to have been limited specifically to these or equivalent forms of the invention. The specification, however, contained a general statement that the described method was particularly applicable to the plates shown in cases B and C.

In case B were shown and described various kinds of corrugated plates, and in case C various kinds of ribbed plates, including perforated plates. The various cross references in these applications were deemed objectionable by the examiner, and the applicant was required to so amend the applications that each should be complete in itself. Accordingly, June 1st, 1882, the applicant filed an amendment, introducing into this case I another sheet of drawings showing perforated plates like those shown in case C, the perforations being packed with porous material.

The interference was originally declared under the title of Swan *v.* Brush, Brush being given the filing date of his original application. This action was based upon the theory that although case I, as originally filed, did not show or describe the perforated plate packed with porous material, the invention was inferentially included therein by the reference to case C. The interference was decided upon the record in favour of Brush by the Examiner of Interferences, no testimony having been submitted by either party. Upon appeal the Examiners-in-Chief reversed this decision, holding that the invention was not included in Brush's application until June, 1882, when he filed the amendment and supplementary drawings, showing and describing specifically the perforated plates. Upon appeal to the Commissioner this decision of the Board was reversed, the Commissioner ruling that Brush was entitled to a record date as of the date of his original application. Upon rehearing, however, it was held by the Commissioner that while the papers in case I, as originally filed, might give authority for the admission of the amendment of June, 1882, the filing of the amendment must give the record date of the invention so introduced into the application under the ruling in the case of *ex parte* Snyder, 22, O. G., 1975. The language of the decision is :

"It is evident that Brush's application clearly illustrating and describing the invention was not filed until the figure illustrating that form of invention had been added to the drawings and a full description had been introduced into the specification. With this understanding of the case, and in the absence of all other testimony, Swan, having been the first to file his complete application within the meaning of Rule 38, must be deemed the prior inventor."

Upon a further motion to rehear and set aside this decision, the Commissioner declined to depart from the position before taken that Brush's application was not complete before the filing of the amendment in June, 1882. Upon the representation, however, of Brush that he would be able to show by parol evidence that he in fact made the invention thus introduced into his application before the record date of Swan, all the decisions in the case were set aside and the case was remanded to the Examiner of Interferences for the purpose of allowing the parties to take testimony in support of their respective claims, the burden of proof in this new proceeding being placed upon Brush. Brush has introduced in evidence the series of applications to which reference has been made, and has also introduced testimony in support of his claim.

So far as his claim to priority of invention rests upon the disclosure furnished by the applications in question, it may now be regarded as definitely settled by the decision of the Commissioner that these applications did not of themselves, as originally filed, and without further explanation, distinctly disclose the invention in controversy. There was not in the range of these applications, as originally filed, a drawing showing a perforated plate packed with porous material, nor was there in all the specifications any distinct description of such invention. The specification in case I referred generally to the various forms of plates shown in cases B and C as suitable for being packed with porous material according to a method therein described ; but in illustrating the proposed invention, the applicant selected from the variety of plates shown in these cases the corrugated and the ribbed or honeycombed plates, thus limiting by these specific examples the more general language of the description.

This interference does not involve broadly the mechanical appliances of porous material to electrodes or plates, but a special improvement in the form of plates so treated. It would be a mere inference to conclude that Brush at the time he filed this application had distinctly contemplated the invention in controversy. As the burden of proof in this case rests upon Brush to show by undoubted evidence that he made this invention prior to the filing date of Swan, it is necessary to resolve any reasonable doubt, such as naturally arises under the circumstances named, in favour of Swan.

The testimony offered by Brush fails to remove the doubt which arises upon the face of the papers. Brush does not state specifically that he at any time invented the subject-matter in controversy. He states that he made drawings showing the invention on or about May 1st, 1881. This allegation, however, must be understood in connection with the facts and circumstances as developed in the testimony. He states that he prepared the original applications, and understood that the cross references in the various applications were equivalent to introducing into each case all that had been described in the other cases. In all this, however, there is no positive statement that he ever contemplated as a matter of fact the treatment of the perforated plate in the manner described. In his own testimony he does not detail the history of his invention further than is involved in the preparation of the applications. He testifies that at least a month before the applications were filed he made pencil drawings for the draughtsman to copy in preparing the applications, adding that several of these drawings fully illustrated the subject matter involved in this controversy. These drawings are not produced in evidence, nor are they described. It appears, however, that they correspond substantially with the drawings originally filed with the specifications, as it is agreed that the drawings were prepared from these sketches. As has been seen, however, the drawings as originally filed did not contain any figure showing a perforated plate packed with porous material.

Brush testifies, it is true, that the drawings filed in cases C, D, and E were copied directly from these sketches. The drawings, however, in cases C and D do not show the invention in controversy. Case E, which has since become patent 274,082, does show perforated sheets packed with porous material. It appears, however, from the record of the case that these drawings were filed as an amendment in June, 1882, and it was admitted by counsel at the hearing that they were made in Washington in June, 1882. It is clear, therefore, that these particular figures were not prepared from the sketches, or at least there is no competent evidence that they were so prepared. It is not shown that the sketches were preserved, or that they were forwarded to Washington. The testimony of Engel on this point must be regarded as a mistake, and as given under a misapprehension of the facts of the case. I fail to see that the testimony advances Brush's case beyond the point before reached. It does not appear that at the time the applications were filed he had made any drawings showing the invention, or that he had disclosed to any one, in conversation or otherwise, the fact that he had made such an invention. The drawings themselves do not even suggest the invention, and there is no evidence that Brush did anything else in connection with this invention except to prepare the applications in question, which, as originally filed, fail upon examination to distinctly describe the invention.

In the meantime Brush must be charged with a knowledge of the art disclosed by Swan's British patent 2,272, of 1881, which was published in this country in the fall of 1881. This patent disclosed to the public full information of the invention in controversy, and it was not until the following year, and presumably after he had been informed of the invention therein contained, that Brush filed the amendment of June, 1882, for the first time illustrating and describing a perforated plate packed with porous material. To overcome the force of the prior publication of the invention it is necessary for Brush to show beyond a reasonable doubt that he had, before the date of the patent, perfected and used the invention, or that, having conceived of the invention before that time, he was using all reasonable diligence in adapting and perfecting the same. The proof of a prior invention to anticipate a prior completed invention or a patent or a printed publication should undoubtedly be clear and positive, both as to the fact of the invention and its reputed date. The only evidence offered in support of his invention to sustain the burden of proof thus placed upon him is the record of these applications and prior sketches alleged to have been made ; the prior sketches, however, are not introduced in evidence. The whole case of Brush is an inference from the remark in case I that the method therein described was applicable to the plates shown in cases B and C ; that he, in fact, proposed to treat the perforated plates shown in case C by the method in case I. The force of this inference is very much weakened by the absence of any positive testimony by Brush while on the stand to the effect that he had made such an invention. At the time the testimony was

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taken the counsel were well aware of the position of Brush's case. The reopening of the case was upon the express understanding that Brush would introduce positive testimony to show that he had made the invention in controversy at least as early as the time of his application. Even if it be presumed that the idea in fact suggested itself to Brush that the perforated plate of case C might be subjected to the treatment described in case I, it is clear that he did not attach any importance to that suggestion, and certainly did not consider it of sufficient significance to specifically illustrate or describe it in the applications which he filed. In this view the suggestion would appear to be a mere random conception which was never followed up or esteemed of any particular value, which left no traces in actual performance, and whose very existence at the time is problematical. I must conclude, from a careful review of the whole case, that Brush has failed to sustain the burden of proof, or, in the language of the Commissioner, "has failed to show that he made the invention prior to the filing of Swan's application." Swan is therefore adjudged the prior inventor.

Limit of appeal, twenty days.

FRANK MACARTHUR,
Examiner of Interferences.

COMPANIES' SHARE LIST.

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Companies.	Closing Prices. June 4.		Business Done Week Ending June 4. Highest.	Lowest.
Anglo-American	31,	32	32½	—
Do. Preferred	57,	58	57¾	—
Do. Deferred	6½,	7	6¾	—
Brazilian Submarine	9¾,	10⅛	10⅛	9 15-16
Cuba	9¾,	10⅛	10¼	—
Do. Preference	16½,	17½	—	—
Direct Spanish	4½,	5	—	—
Do. Preference	14¼,	14¾	—	—
Direct United States Cable	9⅝,	9⅞	9 15-16	9 13-16
Eastern Telegraph	10⅞,	11⅛	11⅛	11
Do. 6 per Cent. Preference	13¼,	13¾	13⅝	13 7-16
Do. 5 per Cent. Debentures, 1899	103,	107	—	—
Eastern Extension	11⅜,	11⅝	11 9-16	11½
German Union	9¾,	10¼	10	—
Globe Telegraph and Trust	6½,	6¾	6⅝	6⅜
Do. Preference	12¼,	12½	12½	12⅜
Great Northern	13⅝,	13⅞	13⅞	13¾
Indo-European	30½,	31½	31	—
Mediterranean Extension	1¼,	1¾	—	—
Do. Preference	2,	4	—	—
Reuter's	8,	8½	—	—
Submarine	150,	160	154	—
West India and Panama	⅞,	1⅛	⅞	13-16
Do. 1st Preference	6½,	7	6 9-16	—
Western Brazilian	5¼,	5½	—	—
Western Union 7 per Cent. 1st Mortgage	121,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	106	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅛,	¼	—	—
Oriental	⅛,	⅜	—	—
United Telephone	8,	8½	8 5-16	8

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1½,	1¾	1¾	1½
Do. (fully paid)	3½,	4	—	—
Hammond Light (£3 15s. paid)	½,	¾	—	—
Eastern Electric (£4 paid)	—	—	—	—
Swan	⅝,	⅞	—	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	33,	34	33¾	33
India Rubber, Gutta Percha, and Telegraph Works	21½,	22¾	23¾	21⅜

TRAFFIC RECEIPTS FOR MAY, 1884.

Companies.	May, 1884.	May, 1883.	Increase.	Decrease.
Cuba Submarine	2,950	3,376	—	426
Direct Spanish Telegraph	1,562	1,641	—	79
Direct United States	—	—	—	—
Eastern Extension	35,910	32,156	3,754	—
Eastern Telegraph	—	—	—	—
Great Northern	24,920	—	—	—
Submarine	—	—	—	—
West Coast of America	4,240	—	—	—
Western and Brazilian	—	—	—	—

PATENTS, DESIGNS AND TRADE MARKS ACT, 1883.

IN THE MATTER of Letters Patent granted to FREDERICK JOHN CHEESBROUGH, of 15, Water-street, Liverpool, in the County of Lancaster, Consulting Engineer, for an Invention of "IMPROVEMENTS IN AND RELATING TO ELECTRIC LAMPS, AND TO A METHOD OF CHARGING SUCH LAMPS WITH AN ARTIFICIAL ATMOSPHERE AND PURIFYING THE SAME, AND TO THE PRODUCTION OF A CARBON FOR USE IN ELECTRIC LAMPS, AND FOR OTHER ELECTRIC PURPOSES," dated 28th November, 1878, No. 4847.

NOTICE IS HEREBY GIVEN, that an application has been made by JAMES YATE JOHNSON, of No. 47, Lincolns Inn Fields, in the County of Middlesex, Gentleman (to whom the said Letters Patent have been assigned), under Sections 18 to 21 of the Patents, &c., Act, 1883, and Rules 48 to 56 of the Rules made thereunder, for leave to AMEND the SPECIFICATION filed in pursuance of the said Letters Patent.

Full particulars of the proposed amendment are published in No. 44 of the Official Journal of the Patent Office, and the Specification as proposed to be amended can be inspected at the Patent Office.

Any person intending to oppose such application must leave particulars in writing of their objections to such proposed amendment at the Patent Office, 25, Southampton Buildings, Chancery Lane, London, W.C., within one calendar month from this date.

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NOTES.

CABLE REPAIRED.—The cable between Maranham and Para is repaired.

DEATH OF MR. SABINE.—Mr. Thomas Richard Sabine died at Southsea on the 7th inst. at the age of 74 years.

"THE GREAT EASTERN."—It is not improbable that this vessel may be used as a hospital ship in the Thames.

THE TELEPHONE IN JAMAICA.—An exchange is to be opened at Kingston, Jamaica, by the West India Telegraph and Telephone Company.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 6th inst. amounted to £3,029.

THE HASTINGS ELECTRIC LIGHT COMPANY.—We believe that the management of this company is to be handed over to the Hammond Company for two years.

MUNICH.—It is said that the municipal authorities of Munich are in treaty with Mr. Schuckert, of Nürnberg, for the lighting of several streets in their town.

NEW BOOK.—We have received a copy of the third edition of "Telegraphy," by W. H. Preece, F.R.S., and J. Sivewright, M.A., published by Messrs. Longmans, Green, and Co.

HENLEY'S TELEGRAPH WORKS COMPANY.—This company's City offices, at No. 8, Draper's-gardens, E.C., are now in connection by telephone with the works at North Woolwich.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of May, 1884, amounted to £51,537, and to £42,960 in the corresponding period of 1883.

SOCIETY OF CHEMICAL INDUSTRY.—This society will hold its annual meeting in Newcastle-on-Tyne on the 9th, 10th, and 11th of July. The president will be Mr. Walter Weldon, F.R.S.

GOVERNMENT TELEGRAPHS IN AMERICA.—The Bill offered by the Senate Committee on Post Office and Post Roads proposes competition between the Government and private companies.

LONDON AND DERBY ELECTRIC WIRE COMPANY.—A petition for the winding up of this company was presented on the 6th instant, and will be heard before Mr. Justice Chitty on the 21st inst.

"THE ELECTRICIAN'S POCKET BOOK."–Under this title Messrs. Cassell and Co. are about to publish a translation by Mr. Gordon Wigan, M.S.T.E. and E., of M. Hospitalier's "Formulaire Pratique de l'Electricien."

WESTERN ELECTRIC COMPANY.—This company, whose rise and progress we briefly sketched in a note in our last issue, have established an office at 59, Moorgate-street, E.C., where their manufactures can be inspected.

FAURE ACCUMULATOR COMPANY.—A petition for the winding up of this company was presented on the 3rd inst. by several shareholders, and is directed to be heard before Vice-Chancellor Sir James Bacon to-day (Saturday).

NOTICE OF REMOVAL.—The Hammond Electric Light and Power Supply Company have removed their offices from 110, Cannon-street, E.C., to their works, Appold-street, Finsbury, E.C., close to the Broad-street Railway Station.

SCIENCE IN FRANCE.—The French Association for the Advancement of Science will hold its annual congress at Blois under the presidency of M. Bouquet de la Grye, Member of the Institute, on the 4th to the 11th September next.

THE TELEPHONE IN PROVIDENCE (U.S.).—The Providence (Rhode Island, U.S.) Telephone Company had 2,812 subscribers on the 13th May last, an increase of 409 on the previous year. The company has nearly 1,900 miles of wire in use.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 6th June, 1884, were £2,359, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

WALSALL AND THE ELECTRIC LIGHT.—The Walsall Town Council have agreed to the request of the Incandescent Electric Lighting Company for a further extension of time for depositing capital under the electric lighting provisional order relating to this town.

THE TELEGRAPH AND TELEPHONE IN VICTORIA.—News from this colony says that Mr. Berry has decided to leave to the new Postmaster-General the consideration of the questions of reducing the price of telegrams and the proposed purchase of the telephone system.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half-month ended the 31st May are £3,205, as compared with £3,048 in the corresponding period of 1883. The February receipts, estimated at £5,408, realised £5,548.

EARTHQUAKES.—A rather severe shock of earthquake, lasting six seconds, was felt on Friday, June 6th, at Aleppo. No loss of life or serious damage is reported. The direction of the shock was from east to west. On the previous morning two slight shocks were felt at Smyrna.

ELECTRIC LIGHTING IN PARIS.—During the recent Fête de la Presse, given in the Bois de Boulogne on the 7th and 8th instant, the Edison Company lighted the ball room, restaurant, &c. Fifty-five A lamps and 60 B lamps were used. The lighting is said to have given great satisfaction.

ELECTRIC LIGHTING IN MILLS.—The Anglo-American Brush Electric Light Corporation have received an order from Messrs. Illingworth and Sons, of Whetby Mills, Bradford, Yorks., for a No. 7 Brush arc machine and fifteen 2,000 candle-power Brush arc lamps, to be used for lighting their spinning mills in that town.

ANOTHER ATLANTIC CABLE.—The *Anglo-Brazilian Times*, in its issue of May 15, has the following notification: "His Imperial Majesty has consented to entitling the D. Pedro II. American Telegraph and Cable Company, the company formed to connect Ceará by a telegraph cable with the United States."

MAGNETO AND DYNAMO MACHINES.—Mr. J. A. Fahie's pamphlet of 53 pp., describing the various kinds of dynamo machines that have been constructed, has reached a second edition, and has been revised and enlarged by the author. It is published by Mr. J. Falconer, of Dublin, and Messrs. Spon, of Charing-cross, S.W.

AN ELECTRIC LIGHTING CASE.—The proprietors of the Royal Lyceum Theatre, Edinburgh, have refused to pay the bill, of £1,700 odd, presented by the Jablochkoff Electric Light Company for an installation effected in that theatre

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some time since. The case is to come before the Court of Session on the 3rd July.

INDUCTION.—On Friday week, at a meeting of the Royal Institution, Mr. Willoughby Smith read a paper in which he referred to some peculiar inductive results that he had obtained, results which did not agree with some which had been described by Faraday. We hope to be able to refer to this paper in greater detail later on.

THE FRENCH ACADEMY OF SCIENCES.—M. Jamin has been elected life secretary of this academy in the place of M. J. B. Dumas, deceased. M. Jamin obtained 39 votes, against 12 given for M. Vulpian, and 1 each for MM. Blanchard and Daubrée, the total number of voters being 53. M. Jamin's election leaves a vacant place in the physics section.

THE TURIN EXHIBITION.—A portion of the Turin Electrical Exhibition, consisting of the *salon* of Signor Nigra, is to be lighted by means of one of the Anglo-American Brush Corporation's D_2L Victoria machines working 125 Victoria 20 candle-power incandescent lamps. The recent improvements in the manufacture of this lamp have given it great durability and equality.

FRENCH OPERATORS.—The Friendly Association of French Postal and Telegraph *Employés*, which already numbers 1,500 members, held their annual dinner on Sunday last in the Grand Hotel, Paris. The chairman was M. Guillebert, president of the association, and he was supported by M. Cochery, Minister of Posts and Telegraphs, and M. G. Cochery, nephew of the Minister.

TELEGRAPH MATERIALS WANTED.—The Highland Railway Company require tenders for the supply of galvanised wire, telegraph instruments, and fittings for one year from 1st July. Forms of tender can be had on application to Mr. J. G. Bulmer, storekeeper, Inverness. Tenders addressed to the directors must be lodged with the secretary, Mr. A. Dougall, Inverness, by the 21st instant.

INTERNATIONAL TELEGRAPHIC MONEY ORDERS.—A convention for the establishment of a new system of telegraphic postal orders has been agreed to between the French Government and that of the Grand Duchy of Luxembourg. The payee, says the *Daily News*, receives at his house an advice by telegraph to the effect that the money due to him will be paid on application to the postal authorities.

THE TRANSMISSION OF POWER.—Experiments on the transmission of power will take place between Paris and Creil in September next. Endeavours will be made to transmit 100 horse-power to a distance of fifty kilometres by means of dynamo machines. The firm of Rothschild will defray all expenses in connection with these experiments, which will be carried out under the superintendence of M. Marcel Deprez.

GOLDEN STREETS.—The well-known French electrician, M. Louis Maiche, has found that there is gold to be obtained from the quartz with which the roads round Paris are paved. M. Maiche has extracted small quantities of the precious metal by crushing the stone and treating it with mercury. We have not yet heard of the formation of a company for working the streets of Paris to obtain this gold, nor do we suppose that there will be much of a rush for the new "diggings."

NEW HOUSE OF PARLIAMENT AT BERLIN.—The electric light is to be employed in the new German House of Parliament, the foundation stone of which was laid at Berlin by the Emperor William on the 8th instant. The telephone will also be employed throughout the building. As the work of erection is estimated to take six to eight years it is probable that considerable advances will have been made in both electric lighting and telephony before the wires for either system have to be laid.

UNDERGROUND WIRES IN CHICAGO.—The Chicago Sectional Electric Underground Company obtained a preliminary injunction towards the end of last month restraining the City of Chicago, the Baltimore and Ohio Telegraph Company, the Commissioner of Public Works, and the Baltimore and Ohio Railroad Company from laying telegraph conduit pipes under Jackson or La Salle-street, on the ground that a monopoly of underground telegraph business was given to the company by a city ordinance.

ELECTRIC LIGHTING IN BERLIN.—The Anglo-American Brush Electric Light Corporation have recently supplied to their agent in Germany, Herr Pleive, of Berlin, two of their D_2 Victoria machines, one B_2, and a No. 8 forty-light Brush arc machine. The two D_2 and the No. 8, together with a No. 5 Brush machine, which they are about to supply, and which is to work a single powerful light, are to be employed for lighting the Hygienic Exhibition at Berlin by means of their Victoria lamps and forty of the new Brush-Sellon lamps.

SAFETY LAMPS.—Two models of safety lamps have been adopted by a committee nominated by the Prefect of the Paris Police to report upon the best lamp for use in a gaseous atmosphere. One of these is an electric lamp supplied with current by an accumulator, and the other is an improved Davy lamp. The Paris firemen are to be supplied with these lamps without delay. This action of the Prefect has been taken with a view to prevent similar accidents to that which happened in the Rue St. Denis a short time since, whereby several firemen lost their lives from an explosion of gas.

ELECTRIC LIGHTING IN FRANCE.—The Edison Company, of Paris, have lighted the factory of Messrs. Dubois, Charvet, Colombier and Co., at Armentières, with 200 A lamps. They have also installed 25 A lamps in the Lens Mines, and Messrs. Masurel Brothers, of Tourcoing, who have been using 60 lamps for the last year, have just given orders for 200 more. Baron Alphonse de Rothschild is going to have 120 A lamps fitted up in the Chateau de Ferrières; the same number are to be placed in M. Menier's Hôtel, and Messrs. Parfait and Dubois, of Avesnes, will have 200 in their factory.

ROYAL SOCIETY.—A *conversazione* was given by this society at Burlington House, Piccadilly, on Wednesday evening. There was, as usual on these occasions, an interesting exhibition of scientific apparatus. Amongst other things was an artificial cable exactly corresponding in resistance and capacity to the Mackay-Bennett Atlantic cable, part of which has just been laid by Messrs. Siemens Brothers. Muirhead's system of duplex working and Sir William Thomson's recorders were shown in connection with this, and the working of the line illustrated thereby. Thomson's wave motion machine and double pendulum apparatus, Stroh's curve writer, and other apparatus were also shown.

ELECTRICITY: ITS APPLICATION TO MOTIVE POWER.—Last month Mr. A. Reckenzaun, C.E., gave a lecture before the Clerk of Works Association on "Electricity: Its Application to Public Works and Buildings—Motive Power," which has been reprinted *in extenso* in the *Journal* of this association. In this lecture Mr. Reckenzaun says: "Two pounds of zinc will,

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in a well-arranged battery, produce energy equal to one horse-power for one hour. Two pounds of coal in a well-arranged steam engine will also yield one horse-power for one hour. But the two pounds of zinc cost sixpence at the wholesale price, and two pounds of coal, at the rate of 18s. the ton, cost hardly ·2d., or nearly one-thirtieth of the price of zinc."

TELEPHONE WIRES IN BRAZIL.—The *employés* of the Telephone Company in Rio de Janeiro have great difficulty in keeping their wires intact owing to the constant damage inflicted by the Aasgeier, a large vulture, which is very common in Brazil. This bird, owing to its habit of just skimming the tops of the houses in its flight, frequently comes in contact with the telephone wires, and either breaks or becomes entangled in them. It appears that there is a law against the destruction of this bird, which does useful work as a scavenger, and consequently there is nothing for the telephone people but to grin and bear it. A local paper suggests that they must wait until the Aasgeier learns to avoid the wires. The wait will be a long one we expect.

TELEGRAPH CLERKS' CONFERENCE. — The fourth annual conference of the Postal Telegraph Clerks' Association has just been held at Birmingham, and was attended by delegates from the principal telegraph centres. The question of gratuitous Sunday labour was discussed, and it was unanimously resolved to again bring the matter before the Postmaster-General. In London all Sunday work is paid for as overtime, but in the provinces no extra payment is given for the duty. It is contended that, as the provincial clerks are called on to perform duty on twelve Sundays in the year, they are entitled either to an overtime allowance or an equivalent in annual leave. The women portion of the staff perform no Sunday duty, but are entitled to the same annual leave, and receive salaries equal to many of the male clerks.

ELECTRIC LIGHTING IN THE "HOUSE."—In the House of Commons on Thursday, the 5th instant, Mr. Gray asked the First Commissioner of Works whether the experiments with the electric light had turned out satisfactorily. If so, he thought there might be some extension of that light, and a proportionate reduction in the item of £1,950 for oil lamps.—Mr. S. Lefevre said he was at present considering whether the electric light should not be applied to every part of the House except the chamber in which they sat. He hoped that with the introduction of the electric light the ventilation of the House, which had been complained of by several members, would be improved.—Later on Mr. Guest suggested that telephones should be placed in the members' rooms, so that the earliest information might be obtained through them.—Mr. S. Lefevre said he would ascertain the views of members on the matter.

THE BRITISH ASSOCIATION'S VISIT TO CANADA.—It is understood that about 700 members have signified their intention of taking part in the meeting at Montreal in August next, and that the arrangements are now complete. Excursions have been arranged so as to give members an opportunity to visit different places of interest, to acquire some information respecting the educational system of the country, and as to the resources and capabilities of the various parts of the Dominion. Some will travel by way of Halifax, and visit the maritime provinces and Quebec before the opening of the proceedings, while others will take this part of the journey on their way home. A liberal subsidy has been given by the Montreal Committee towards the passages of qualified members, and it is assumed that persons accepting this subsidy will remain at Montreal during the continuance of the sitting.

DYNAMOS.—A French contemporary says:—"For some time past there has been considerable discussion as to the invention of dynamos. Certain electricians, roused by the undoubted success of the Gramme machine, have hunted up prior rights to his, and have striven to take from his merits. They have opposed him with the Pacinotti ring, Professor Silvanus Thompson having come forward to establish its priority, as we saw not long since. It is not for us to refute opinions like these. The following telegram, sent from Turin this week to M. Gramme, settles the question definitely:—'Exhibitors and organisers of the Turin Electrical Exhibition, dining together, salute Monsieur Gramme, first inventor of practical (*industrielles*) dynamo machines.' Even the compatriots of Pacinotti recognise in M. Gramme the inventor of practical dynamos. This is in our opinion the highest title that the latter can claim, and we heartily join in the sentiment expressed by the electricians of Turin."

ELECTRIC LIGHTING AT A DANCE.—At a dance given on Wednesday, the 11th inst., by Sir George Grove, at Lower Sydenham, the electric light was used to illuminate the various rooms, with great effect. The lamps, 20 Woodhouse and Rawson and Swan, 20 candle-power, 42 volts, were fed by a Newton compound shunt dynamo, driven by a portable engine placed across the road about 100 yards off, and used during the day for sawing wood. As the house is already wired for electric light, all that it was necessary to do was to hang the cable over the road and connect on to the house mains. The rooms were quite cool, and general admiration was expressed at the effect. One of the young ladies present—Miss Chambers—had a small lamp embedded inside some real flowers, the current being supplied by an accumulator in the pocket of her dress, and the effect was exceedingly pretty. The machine, lamps, &c., were obtained from Messrs. Woodhouse and Rawson; and the whole of the wiring and fixing was done by Mr. A. S. Grove, assisted by Mr. R. T. Turnbull.

PRIMARY BATTERIES.—Without wishing to detract from the merits of the 101 primary batteries that have from time to time been patented and brought before the public by ingenious improvers on old forms of cells, we should like to warn our readers that the cant about supplying electricity free of cost, and the highflown statements as to the capabilities of some of these batteries are worth no more than the paper on which they are so freely expressed. Primary batteries may in some cases prove useful as generators of current for a few incandescent lamps, but their utility or otherwise is entirely a question of time and place. To talk about their producing electricity free of cost is to betray an ignorance of ordinary physical and electrical laws which should be quite sufficient to prevent even the general public from swallowing such high-coloured nonsense; whilst many "ifs" crop up in connection with the statement that the residual products can be sold at a profit, which have to be taken into account and seriously reckoned with in plain unvarnished practical work. Primary batteries are useful enough in their way, and there is no need to circulate misleading statements about them to ensure their sale.

ADDITIONS TO THE GENERAL POST OFFICE.—In the House of Commons on Thursday, the 5th inst., there was some considerable discussion on the vote for the Customs, Post Office, and Telegraph buildings.—Sir G. Balfour protested against an increase of £100,000 for telegraph and Post Office buildings being charged to the current revenue, as these buildings would last for many years, and would benefit future generations.—Mr. H. Fowler complained that this vote had rapidly increased

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in the last few years. He thought that a large amount of money was spent unnecessarily in the erection and alteration of post offices. It was urged in extenuation of the failure to carry out the promise to introduce sixpenny telegrams that the revenue of the Post Office would not bear it. This was a reason why the most rigorous economy should be exercised throughout the country in the erection of post offices. As a matter of protest he moved the reduction of the vote by £10,000.—After alluding to the vast increase in the postal business, which necessitated larger buildings, Mr. Fawcett said that nearly £53,000 out of the £100,000 was required for carrying on the work which would be caused by the introduction of sixpenny telegrams. Without the proposed additional story to the building it would be impossible to meet that increased business.—Eventually the vote was agreed to.

CARDEW'S SYSTEM OF WINDING DYNAMO MAGNETS.—The Anglo-American Brush Electric Light Corporation have just supplied to the order of a Colonial Government one of its D_2 100 light Victoria machines. The field magnets of this machine are wound on the system patented and devised by Captain P. Cardew, R.E., of Chatham, and consist in an arrangement whereby the dynamo can be used for working arc, incandescence, or search lights at will. By means of a simple switchboard placed on the machine it is possible to so connect up the coils of the magnet fields as to allow of four powerful arc lights being worked simultaneously; or if four be not required, three, two, or one may be worked in parallel. By this ingenious method of winding the difficulty of working arc lamps in parallel economically has been surmounted; the arrangement at the same time permits of any of the arc lamps being worked independently of the others. By a simple alteration on the switchboard the machine can also be used for working a single powerful hand-regulated search light of 25,000 candles, suitable for naval or military purposes. As well as this, the machine will maintain 100 20 candle-power 60 volt Victoria lamps, and being self-regulating, these lamps may be turned on and off at will in any required number, without attention being paid to the dynamo, the speed remaining practically constant. Further, by this novel winding of Captain Cardew's, it is possible to work satisfactorily arc and incandescence in parallel simultaneously.

GAS AND ELECTRIC LIGHTING. — In the course of his address as president of the Gas Institute, delivered on the 10th inst., Mr. Robert Harris, M.I.C.E., said:—"This address would probably not be considered complete were I not to make some allusion to the electric light. I have purposely left its consideration till the last, feeling that it has now assumed a position of very minor importance as far as the gas industry is concerned. It has been proved, and, judging by the results as shown in the defunct and moribund companies, proved over and over again, that it cannot compete with gas, as now very generally used, at the prices that rule in England. Notwithstanding the failures which have taken place, we, as gas engineers, must not ignore the fact that there is a source of artificial illumination other than the one in which we are more directly interested, which may come into competition with us, and which doubtless will find its position alongside gas in certain places where its peculiar qualities render it more suitable. It has always struck me that the electric light in the incandescent form is particularly well adapted for use for lighting our large ocean-going steamers. The conducting wires might be laid with great facility all over the ship; the lights would be fixed and shielded, so that the danger from fire would be reduced to a minimum; and, further, ample steam power would always be at hand, to be employed for driving the dynamo machines when required. I am informed that several large ships are now so lighted, and with marked success."

DUNDEE MECHANICAL SOCIETY.—The inaugural address of this society was delivered on the 5th inst., to a large audience, by Professor J. A. Ewing, who took for his subject "The Recent Progress in the Practical Applications of Electricity." After tracing the development of the dynamo machine from the time of Faraday's fundamental discovery, the lecturer discussed at length the question of electric lighting. It was pointed out that the jute and linen mills of Dundee formed a field in which electric lighting could be introduced with advantage. A calculation was given of the cost of lighting a mill with 500 20-candle incandescent lamps, from which it appeared that, provided the requisite power could be obtained from existing engines without other outlay than the cost of the extra coal thereby consumed, the price for electricity would be almost the same as the price of an equivalent light from Dundee gas. In this estimate the interest on and depreciation of the electric plant was taken account of, as well as the renewal of lamps, coal, oil, and attendance. But while the cost would be nearly the same the difference in comfort and health to the workers would be immense. Moreover, the ease and safety with which electric lamps could be put just where they were wanted would enable the same total amount of light to be more advantageously disposed. As an example of this, Professor Ewing cited the case of spinning frames, in which with gaslight the quick detection of a broken thread was difficult. A mill manager had told him that the output of the frames was 7 per cent. less during the winter months, when gaslight was used, than during the summer months, and his informant ascribed this to the difficulty of seeing the threads in gaslight. The lecturer suggested that a possible remedy, worth trial at least, would be to put electric lamps inside the frames, so that the threads would show as dark lines on a bright ground.

THE TELEPHONE AND THE POST OFFICE.—A memorial has been presented to the Postmaster-General by the Edinburgh Chamber of Commerce, asking Her Majesty's Government to grant such facilities as will encourage and develop the telephone system, without unduly interfering with the revenue of the Post Office. In an article commenting on the above memorial the *Edinburgh Courant* attacks the policy of the Post Office in connection with the telephone without stint. It characterises the proceedings of the department subsequent to the compromise between it and the telephone companies as consisting of "vexatious, frivolous, factious interference of every kind." The rent of £10 per mile per annum charged by the Post Office for trunk lines is, our contemporary says, exorbitant, and illustrates "how carefully swaddled in officialism and ingeniously red taped the whole supervision of these trunk wires is." Further on we read that "in every single case in which a Government telephonic exchange has been established, with the solitary exception of Newcastle-on-Tyne, where a moderate success has resulted, the experiment has been a total failure. On the other hand, notwithstanding the restrictions under which the business is conducted, there is no instance of a telephonic exchange carried on by private enterprise being otherwise than a success." The *Courant* concludes as follows:—"It is surprising that a great political economist, such as Mr. Fawcett is admitted to be, should have taken the line he has done. No doubt the permanent heads of the department have a great deal to answer for. Be this as it may, we have no hesitation in saying that

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very shortly public opinion will be so educated upon the question that the narrow-minded officialism which presently obtains will be swept aside, and the public will be allowed the free use of what is undoubtedly at once the greatest scientific marvel and the most perfect business facility of our time."

GREENWICH OBSERVATORY.—On Saturday last the Board of Visitors of the Royal Observatory at Greenwich paid their annual visit to that establishment to inspect the instruments and receive the report of Mr. W. H. M. Christie, Astronomer Royal, for the year ending 20th ultimo. Several members of the Royal Society also visited the Observatory on the invitation of their president. The following extracts from the report may interest our readers:—The sun has been photographed on 219 days, on only four of which the disc was free from spots; the greater number of photographs compared with former years is due to a great extent to the use of dry plates, as a photograph can be secured now when the sun is visible even for a few minutes. The Greenwich time ball was not raised on two days on account of high wind; on the remaining 363 days it was successfully dropped. The ball at Deal was not raised on nine days, and failed to drop on 16 days owing to failure in the telegraphic connection. Since February 29th this ball has been dropped through the Post Office telegraphs instead of the South-Eastern Railway Company's wires. The Westminster clock has performed satisfactorily, the error being less than one second on 53 per cent. of the days of observation, and over three seconds on only 4 per cent. In the Magnetic Department the time of vibration of the magnets has been so adjusted that the movements recorded on the photographic sheets for vertical force, horizontal force, and declination are directly comparable. There were only five days of great magnetic disturbance in 1883. Tracings of the magnetic registers have been reproduced by photo-lithography to supersede the tables of ordinates in the Greenwich volume of observations. The number of hours of bright sunshine recorded was 1,241, or about 30 hours above the average of the preceding six years. No connection was remarked between magnetic disturbances and the red sunsets of the past winter.

THUNDERSTORMS.—Towards the end of last week severe thunderstorms occurred in various parts of England. On Thursday, the 5th instant, Nos. 1 and 2, Clarendon-villas, Dovercourt, near Harwich, were struck by lightning. Considerable damage was done to the furniture in No. 1, and the basement was set on fire. It may be mentioned also that every one of the fire-stoves in No. 1 were dislodged. No one appears to have been hurt. A storm visited London on the same day at about 2 p.m., during which a man named Fennell, the gate-keeper at Lord's Cricket Ground, St. John's Wood, was struck and rendered insensible for some time. The flash then caught the back room of No. 3, Grove-road, in the rear of Lord's, and filled the room with a sulphurous vapour. In the basement it fused a gas-pipe, and set the gas alight as it escaped. On Saturday during a heavy thunderstorm at Halesowen a woman named Phœbe Harris was killed by lightning. In consequence of the violence of the storm the deceased caused seven children to assemble in the kitchen. She picked up a grandchild, and when in the act of sitting down was struck dead by lightning, and the whole of her hair burnt off her head. The child, which was clasped tightly in deceased's arms, was unhurt. At Great Alne, near Alcester (Warwickshire), Mr. Sidney Bemford, farm bailiff, had his horse killed as he was sitting on it talking to another man. The flash rendered both men insensible for hours. At Chorley (Lancs.) a house in Clifford-street and two houses in Seymour-street were struck, much damage being done to furniture, but no personal injuries resulting. A house at Pemberton was also struck and the chimney demolished. At Hartpury in Gloucestershire a mare and her foal were killed by lightning, and at Longhope near this place a flock of eighteen sheep were killed. On Sunday a house in the Avenue at Clifton, Bristol, was struck and the chimney destroyed, and at Birmingham a Congregational chapel was struck. Here the current appears to have passed half way down the conductor, then forced some masonry out of the wall, caused an explosion of gas, smashed gas brackets near the organ, and hurled a portion of a bracket into the body of the church, striking a man on the back. The watches of the organist and several choristers were stopped, and the organ blower's hat was carried from his head some distance away. A panic was with difficulty prevented. Fortunately no one was injured, chiefly owing to the presence of mind of the minister, who begged the congregation to keep quiet and remain seated.

PRIVATE LIGHTING.—An interesting installation of the electric light has just been completed at Linden Park, near Hawick, the residence of Mr. Walter Laing. Linden Park is about two miles from Hawick, and the house is a new one, only just completed. A small stream—a feeder of the Teviot—runs through the grounds, and advantage has been taken of this to obtain power for producing electricity for lighting the mansion and stables. A turbine wheel has been erected capable of giving off about eight horse-power and requiring about 270 cubic feet of water per minute when working at full power. As the stream will not in dry weather give nearly so much as this, a reservoir, in the shape of a small lake of about an acre in extent, has been constructed in the bed of the rivulet. In the driest weather the stream may be depended upon to give at least 80 cubic feet per minute, and this being stored up in the reservoir during the daytime, more than sufficient force is obtained for working the turbine when the lights are required at night. The turbine is fixed in a small building, and is connected by a short belt with the dynamo, which is a Siemens compound self-regulating machine, capable of supplying about 70 Swan incandescent lamps of 16 candle-power each. From the dynamo the necessary conducting wires are carried up to the house, partly on posts overhead and partly underground, branches being taken off to supply the stables and the avenue from the lodge. About 100 Swan incandescent lamps have been fitted up altogether, and of these 70 can be worked at once, and all or any can be turned on or off at pleasure. Most of the lights are of about 16 candle-power, but a few are 32. About 80 lights are distributed through the house, lighting every portion, no other kind of light being provided for. Seven lights are taken up in lighting the stables, and 12 outside. These latter are all controlled by one switch near the hall door, and can either be lighted or extinguished instantly. The distance of the turbine and dynamo from the house is about 350 yards, and from the house to the lodge about 400 yards. For stopping the turbine at night when the lights are no longer required a simple electrical arrangement has been designed, by means of which the sluice valve can be closed from the house without going down to the turbine house. The whole of the electrical portion of the work was entrusted to and successfully carried out by Messrs. J. Edmundson and Co., electric light engineers, of 19, Great George-street, Westminster, S.W. This is a good specimen of the class of work which could readily be carried out at many country houses, and we have no doubt that as the convenience and healthy properties of the incandescent system become more generally known similar installations will be common.

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ELECTRO-CHEMISTRY.—Inorganic.

BY DR. G. GORE, F.R.S.

(CONTINUED FROM PAGE 78.)

Separation of Zinc. — Zn. Electro-chemical equivalent $=\frac{65}{2}=32\cdot5$. A dyad cation. Only the most highly positive metals usually set free zinc from its solutions. From slightly acid solutions of zinc salts magnesium deposits the metal and hydrogen gas (Roussin, *Chem. News.*, Vol. XIV., p. 27). According to S. Kern, magnesium evolved hydrogen very slowly from a solution of zinc chloride (*Jour. Chem. Soc.*, 1876, Part I, p. 684). Sodium amalgam immersed in a concentrated solution of zinc sulphate forms a viscid amalgam of zinc (Böttger, Watts's "Dictionary of Chemistry," Vol. III., p. 891). Joule also obtained amalgams of zinc by electrolysis, using a cathode of mercury (*ibid*). From an alkaline solution of a salt of zinc aluminium easily separates the metal (A. Cossa, Watts's "Dictionary of Chemistry," Vol. VII., p. 54). I observed that in a solution of either nitrate, chloride, sulphate, or acetate of zinc neither antimony, bismuth, platinum, gold, silver, copper, brass, German silver, nickel, iron, tin, lead, or zinc becomes coated with zinc by simple immersion. I heated a mixture of 1·5 grain of crystals of silicon and 10·25 grains of perfectly dry fluoride of zinc in a porcelain crucible to a full red heat; the salt was decomposed and zinc set free. According to V. Roque, wrought and cast iron previously dipped in a strong solution of potassic carbonate, became coated with zinc by simple immersion during from three to twelve hours in a solution composed of 1,000 parts of water, 10 of chloride of aluminium, eight of potassic bitartrate, five of stannous chloride, four of acid sulphate of aluminium, and four of chloride of zinc (*Chem. News*, Vol. XXI., p. 288).

Raoult states that gold or copper in contact with zinc, in a concentrated and boiling solution of chloride or sulphate (but not nitrate) of zinc, acquires a deposit of zinc. But gold in contact with antimony, silver, copper, nickel, iron, or lead, in cold or boiling acid or neutral solutions of salts of zinc, receives no such coating (*Chem. News*, Vol. XXVI., p. 240; Vol. XXVII., p. 59. *Jour. Chem. Soc.*, Vol. XI., p. 464). Copper or brass immersed in contact with zinc in a boiling saturated solution of chloride of ammonium acquires in a few minutes a specular coating of zinc, but in a solution of cream of tartar no such deposit occurs (R. Böttger, "Gmelin's Handbook of Chemistry," Vol. I., p. 50; also *Chem. News*, Vol. XXII., p. 108). Copper acquires a fixed and brilliant coating of zinc by immersing it in contact with zinc in a hot concentrated solution of potash or soda (F. Weil, *Chem. News*, Vol. XIII., p. 2).

By means of a separate current and a zinc anode zinc has been deposited from solutions of several of its salts, viz., the chloride, ammonio chloride, sulphate, ammonio sulphate, acetate, tartrate, &c. According to Smee, a solution of zinc oxide in caustic potash is not a good conductor, the zinc anode does not readily dissolve in it, and similarly with the potassio tartrate and potassio cyanide.

Electrolysis of Chloride of Zinc.—$Zn.Cl_2$. Molecular weight = 136. Fused zinc chloride is reduced to metal by contact with aluminium (Flavitzky, Watts's "Dictionary of Chemistry," Vol. VIII., Part I., p. 64). It has been stated that perfectly clean iron acquires a thin coating of zinc by simple immersion in a solution of 30 parts of zinc chloride and 1 of sal-ammoniac (Watts's "Dictionary of Chemistry," Vol. VIII., Part 2, p. 1,118). According to Grove, nitride of zinc is formed at an anode of zinc in a weak solution of sal-ammoniac (Watts's "Dictionary of Chemistry," Vol. V., p. 1,072).

Electrolysis of Sulphate of Zinc.—$Zn.SO_4$. Molecular weight = 161. Sodium amalgam in contact with a strong solution of this salt forms a viscid amalgam (Böttger). Joule formed the same compound by making mercury the cathode in that liquid. From a solution of the sulphate, magnesium deposits with strong action a mixture of zinc, its hydrated oxide, and sulphate (Commaille, *Chem. News*, Vol. XIV., p. 188.)

By means of a current from two Smee's cells, with a large zinc anode, a solution of one part of zinc sulphate in five to ten parts of water may be made to yield a good deposit of zinc. According to V. Meyer, pure zinc may be obtained by the electrolysis of an ammoniacal solution of its sulphate with a sheet zinc anode and a copper wire cathode (*Jour. Chem. Soc.*, Vol. X., 2nd Series, p. 221; *see* also Watts's "Dictionary of Chemistry," Vol. VII., p. 1,213).

MM. Person and Sire easily deposited zinc "on any metal," by the separate current process, with a single cell and a zinc anode, from a solution of one part of oxide of zinc dissolved in 100 parts of water containing 10 of alum (*Chem. News*, Vol. II., p. 275).

Electrolysis of Cyanide of Zinc and Potassium.—A. Watt makes a mixture composed of twenty gallons of distilled water, 200 ounces of cyanide of potassium, and eighty by measure of the strongest aqueous ammonia. He then fills several large porous cells with a solution composed of sixteen ounces of cyanide of potassium to each gallon of water, and partly immerses them in the other liquid. In the porous cells he places sheets of copper or iron to act as cathodes, and in the outer liquid clean pieces of zinc to act as anodes, and connects the battery in the usual way until about sixty ounces of zinc are dissolved, and then stops the current and removes the porous vessels. He next dissolves eighty ounces of carbonate of potassium in a part of the zinc solution, and returns it to the original portion, and stirs the mixture thoroughly. After the sediment formed has subsided he decants the clear liquid for use. Articles of iron may be coated in this liquid. Anodes of zinc are employed, and a little cyanide of potassium and liquid ammonia are occasionally added if necessary. The battery preferred is composed of two Bunsen cells.

Deposition of Alloys of Zinc and Copper.—As early as the year 1841 M. de Ruolz deposited brass, by means of the battery process, from a solution of the mixed cyanides of copper, zinc, and potassium. One of the best solutions for yielding brass by means of a separate current is that of Morris and Pershouse. It is composed of one pound of potassic cyanide, one of ammonium carbonate, two ounces of cupric cyanide, and one of cyanide of zinc, dissolved in one gallon of water, and the liquid used at 150° F., with a strong current and a large brass anode. To increase the proportion of copper in the deposit, either add potassic cyanide or raise the temperature, and to increase that of the zinc, add ammonic carbonate or lower the temperature. Walenn recommends a solution composed of equal parts of ammonic tartrate and potassic cyanide dissolved in water, and after addition of the cyanides of copper and of zinc the oxides of those metals are also added to the solution. If upon trial hydrogen is set free at the cathode, a little ammoniuret of copper is also added to the mixture. There is then no liberation of hydrogen, and a deposit of brass may be obtained of any desired thickness. Two or three Smee's cells are sufficient (*Chem. News*, Vol. XXI., p. 273, Vol. XXII., pp. 1 and 181; *Jour. Chem. Soc.*, Vol. X., p. 103; and *Phil. Mag.*, 4th Series, Vol. XLI., p. 41). In depositing from an electro-brassing solution, which contains cyanide of potassium and tartrate of ammonium, at a temperature but little above the freezing point, nearly pure zinc forms upon the cathode (Walenn, *Chem. News*, Vol. XXXV., p. 154; see also Watts's "Dictionary of Chemistry," Vol. VII., p. 382).

Deposition of Alloys of Zinc, Copper, and Nickel.—A solution described by Morris and Johnson for depositing German silver is composed as follows:—Dissolve one pound of potassic cyanide and one of carbonate of ammonium in a gallon of water. Heat the solution to 150° F. Immerse it in a large anode of German silver and a small cathode of any suitable metal, and pass a strong current until a large quantity of the alloy has dissolved and a bright cathode receives a good deposit of the desired alloy. If the deposit becomes too red,

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add ammonic carbonate; if too much of the appearance of zinc, add potassic cyanide.

Various other mixtures for depositing brass and German silver may be found described in works on electro-metallurgy.

For the electrolytic anylysis of compounds of zinc see *Chem. News*, Vol. XXIV., pp. 100 and 172; Vol. XXXV., p. 264; Vol. XLIII., p. 61; Vol. XLIV., p. 304; and Vol. XLVI., p. 105. *Jour. Chem. Soc.*, 1877, Part I., 340, and Part II., pp. 804 and 924; Vol. XXXVIII., 1880, p. 584; Vol. XL., 1881, pp. 1,081, 1,101, and 1,170; Vol. XLII., 1882, pp. 896 and 1,320; and Vol. XLIV., 1883, p. 122. *The Chemist*, New Series, Part XVIII., March, 1855, p. 334. Watts's "Dictionary of Chemistry," Vol. VIII., Part I., p. 712.

For the electro-metallurgy of zinc *see* Luckow, *Jour. Chem. Soc.*, Vol. XLII., 1882, p. 431; and the separation of zinc and silver, by W. G. Blagden, *see* Watts's "Dictionary of Chemistry," Vol. VI., p. 1,026.

Separation of Magnesium.—Mg. electro-chemical equivalent $\frac{24\cdot3}{2} = 12\cdot15$. A dyad cation. Fused magnesic chloride is not reduced to metal by contact with aluminium (Flavitzky, Watts's "Dictionary of Chemistry," Vol. VIII., Part I., p. 64). An amalgam of potassium or sodium decomposes a solution of magnesic sulphate by simple contact, and produces magnesium amalgam. Electrolysis of that liquid into a cathode of mercury also produces it (Klauer, Watts's "Dictionary of Chemistry," Vol. III., p. 888; *Jour. Chem. Soc.*, 1876, Part I., p. 684). I melted to a perfect liquid, at nearly a white heat, a mixture of six grains of magnesic fluoride and four of calcic fluoride, and then added two grains of crystals of silicon. The crystals did not dissolve, and there appeared no signs of magnesium having been separated. The electrolytic decomposition of the double chloride of magnesium and sodium in a fused state by contact with sodium is the ordinary process of obtaining the metal.

(TO BE CONTINUED.)

THE INDUCTION OF CURRENTS IN CORES.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 55.)

The core currents may be allowed to flow or not, by, in the latter case, a suitable division of the core into insulated parts. We then have merely the insignificant currents which the dielectric will permit. We make no count of the heating from this cause, which will be considered later. Also, the alternate magnetisations and demagnetisations occurring in the core are supposed to be of the conservative character, involving no dissipation of energy at all when the currents are not allowed to flow. I do not know whether it has been definitely established that there is a dissipation of energy going on in iron cores apart from the heating as per Joule's law, although I conclude from indirect experiment that if there be any it is not great with moderate magnetising forces. On the above suppositions we may let the currents flow in the core, or stop them completely, as we please, without removing the core. If it be of a non-magnetic metal, with μ practically equal to unity, the effect on the coil current of insulating the core is the same as removing it altogether. But if it be of iron its insulation and removal are of course not equivalent. Put $\rho = \infty$ to show insulation. Put $\mu = 1$ as well to show removal, which will greatly alter the value of L, the coefficient of self-induction where the core is of iron, and not at all if of copper.

Let $L = L_1$, *i.e.*, let the depth of coil be small compared with its radius, let the core fill the coil opening, and let the external self-induction of the circuit be negligible. Allowing the core currents to flow always diminishes the lag of the coil current behind the impressed force, but the amplitude of the coil current may be either reduced or increased according to the speed and other circumstances, especially the resistance of the coil circuit. First, as regards the lag, that ϵ is always reduced may be thus seen. Put in equations (42) the values of P and Q given by equations (39); then

$$\tan\epsilon = \frac{S\,(MN' - NM')}{R\,(M^2 + N^2) + S\,(MM' + NN')},$$

where S stands for $\frac{L_1\rho}{2\pi\mu c} = \frac{2L_1 n}{xc}$. Now use in this the expressions lately given for the M and N functions in the brackets, and we shall find

$$\tan\epsilon = \frac{\dfrac{L_1 n}{R}}{Y_1 + \left(\dfrac{L_1 n}{R}\right)\dfrac{xr^2}{8}Y_2} \quad . \quad . \quad . \quad . \quad . \quad (48a),$$

where Y_1 and Y_2 are two functions whose values are unity when $y = 1$, and whose full expressions are

$$\left.\begin{aligned} Y_1 &= \frac{1 + \frac{2y}{2^2 4^2}\Big(1 + \frac{3y}{6^2 8^2}\Big(1 + \frac{3\frac{1}{3}y}{10^2 12^2}\Big(1 + \frac{3\frac{1}{2}y}{14^2 16^2}\Big(1 + \frac{3\frac{3}{5}y}{18^2 20^2}}{1 + \frac{6y}{4^2 6^2}\Big(1 + \frac{5y}{8^2 10^2}\Big(1 + \frac{4\frac{2}{3}y}{12^2 14^2}\Big(1 + \frac{4\frac{1}{2}y}{16^2 18^2}} \\ Y_2 &= \frac{1 + \frac{6y}{6^2 8^2}\Big(1 + \frac{5y}{10^2 12^2}\Big(1 + \frac{4\frac{2}{3}y}{14^2 16^2}\Big(1 + \frac{4\frac{1}{2}y}{18^2 20^2}}{1 + \quad . \quad . \quad .} \end{aligned}\right\} \quad (49)$$

the denominator in Y_2 being the same as in Y_1. Now it can be easily seen that Y_1 is greater than unity; this fact, since Y_2 is also positive, makes the denominator in (48) always greater than unity; and therefore $\tan\epsilon$ less than $L_1 n/R$, which is its greatest value, occurring when the core currents are stopped.

But, as regards the amplitude of the coil current, if we call the apparent resistance of the circuit R_1, *i.e.*, what it should be for the same impressed force to give the actual current strength if there were no inductive E.M.F., then, by equation (41),

$$R_1^2 = \frac{P^2 + Q^2}{M^2 + N^2} = R^2 + S^2\frac{M'^2 + N'^2}{M^2 + N^2} + 2RS\frac{MM' + NN'}{M^2 + N^2},$$

which, by the given expressions for the M,N functions, may be written

$$\left(\frac{R_1}{R}\right)^2 = 1 + \left(\frac{L_1 n}{R}\right)^2 Y_3 + \left(\frac{L_1 n}{R}\right)\frac{xr^2}{4}Y_4 \quad . \quad . \quad . \quad . \quad . \quad . \quad (50)$$

in which Y_3 and Y_4 are given by

$$\left.\begin{aligned} Y_3 &= \frac{1 + \frac{3y}{4^2 6^2}\Big(1 + \frac{3\frac{1}{3}y}{8^2 10^2}\Big(1 + \frac{3\frac{1}{2}y}{12^2 14^2}\Big(1 + \frac{3\frac{3}{5}y}{16^2 18^2}}{1 + \frac{2y}{2^2 4^2}\Big(1 + \frac{3y}{6^2 8^2}\Big(1 + \frac{3\frac{1}{3}y}{10^2 12^2}\Big(1 + \frac{3\frac{1}{2}y}{14^2 16^2}\Big(1 + \frac{3\frac{3}{5}y}{18^2 20^2}} \\ Y_4 &= \frac{1 + \frac{6y}{6^2 8^2}\Big(1 + \frac{5y}{10^2 12^2}\Big(1 + \frac{4\frac{2}{3}y}{14^2 16^2}\Big(1 + \frac{4\frac{1}{2}y}{18^2 20^2}}{1 + \quad . \quad . \quad .} \end{aligned}\right\} \quad (51)$$

the denominator in both cases being the same. Now here Y_3 and Y_4 are less than unity, which is their value when $y = 0$, and this permits R_1^2 to be either greater or less than $R^2 + L^2 n^2$, the value when the core currents are stopped. In order that R_1 should be increased or decreased by permitting the core currents to flow, we must have, by equation (50),

$$1 + \left(\frac{L_1 n}{R}\right)^2 Y_3 + \left(\frac{L_1 n}{R}\right)\frac{xr^2}{4}Y_4 > \text{or} < 1 + \left(\frac{L_1 n}{R}\right)^2$$

which is the same as

$$\frac{L_1}{R} < \text{or} > \frac{\pi\mu r^2}{\rho}\,\frac{Y_4}{1 - Y_3} \quad . \quad . \quad . \quad . \quad . \quad . \quad (52)$$

Here L_1/R is the time constant of the coil circuit. Its greatest value is when the coil is short circuited, so we cannot increase it as we like; but by inserting resistance we may diminish it indefinitely. Thus L_1/R may be always made less than the quantity on the right side, and should it be greater when the coil is short circuited, we may, according to the resistance we

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insert, cause the coil current to be either increased or diminished by the reaction of the core currents when the latter are permitted. Noting that Y_4 and Y_3 are fractions which decrease from unity as y increases, that is, as the frequency of the oscillations, and other circumstances before mentioned, making $Y_4/(1-Y_3)$ large when y is small, and small when y is large, we see that in general at low speeds the coil current is likely to be weakened, and at high speeds strengthened by the core currents. The latter effect may be very considerable.

Example 1. *y small.*—Let $y=1$, or $(8\pi^2\mu v r^2)^2=\rho^2$. If the core is of copper, $\rho=1{,}700$, $\mu=1$. Let $c=r=1$ cm., then $8v=170$ gives the frequency required. We find by equations (51),

$$Y_3=\cdot 975, \qquad Y_4=\cdot 972,$$

so that the apparent resistance R_1, by equation (52), is increased by allowing the core currents to flow,

if $\quad L_1/R<(\pi/1{,}700)\div(972/25)$ or 1/15 sec, nearly.

Now, under the circumstances, the time-constant must be less than this value. For, by equations (6) and (9), its greatest value, viz., when coil is short circuited, is given by

$$L_1/R=\pi^2\mu bc^2/c_1^2\rho_1\,(2c+b),$$

in which we must for the present purpose put $\mu=1$. Also $\pi^2=10$, and $c_1{}^2\rho_1$ we may take $=2{,}000$, making

$$L_1/R=bc/400,=b/400,$$

remembering that b must be small compared with c, and that $c=1$. Thus the amplitude of the coil current is in this case reduced by the core currents, whatever the resistance in circuit may be. With the time constant $=\dfrac{1}{4000}$ we find the squares of the apparent resistances as compared with the square of the real resistance to stand in the ratios

$$1:1{\cdot}0011:1{\cdot}0093,$$

the unity being with no core, the second number with self-induction only, the third with core currents also, showing the effect of the latter cause in reducing the coil current to be greater than that of the self-induction alone.

As regards the alteration in the amount of retardation, we find

$$\tan\epsilon=L_1n/R=133{\cdot}5/4000=\cdot 03337$$

with self-induction only; and, by equation (48),

$$\tan\epsilon=\cdot 03337/\,(1{\cdot}0206+\cdot 03337\times\cdot 9922/8)$$
$$=\cdot 03337/1{\cdot}0247=03256$$

when the core currents are permitted to flow. This difference may seem very insignificant, but when two coils are *balanced* against one another far smaller charges are experimentally observable. However, the example is not a favourable one for showing a large difference. If in this example we substitute an iron core, keeping other things the same, with the same value of $y=1$, with a lowered speed to suit the altered permeability and conductivity, we simply multiply the former time-constant by the new value of μ, and we shall find, unless μ is exorbitantly large, that the small value $y=1$ still does not permit the coil current to be increased by the core currents. To get this result we must raise the now lowered speed, give a larger value to y, and we shall find the coil current much increased.

Example 2. $y=40^2$. Iron core.—Let $\mu=100$, $\rho=10{,}000$, $c=1$, and $v=50$. Then $x=40$, and $y=40^2$.

Here we find $M^2+N^2=198{\cdot}25$, showing that the amplitude of the magnetic force at the core's boundary is 14 times that at the axis. We also find

$$Y_1=4{\cdot}454,\quad Y_2=\cdot 176,\quad Y_3=\cdot 089,\quad Y_4=\cdot 039;$$

and these values inserted in equations (48*a*) and (50) give us

$$\left(\frac{R_1}{R}\right)^2=1+\cdot 089\left(\frac{Ln}{R}\right)^2+\cdot 396\left(\frac{Ln}{R}\right)\quad . \quad . \quad . \quad (53),$$

and
$$\tan\epsilon=\frac{Ln/R}{4{\cdot}454+\cdot 881\,Ln/R}\quad . \quad . \quad . \quad . \quad . \quad . \quad (54),$$

where Ln/R may be varied considerably.

By equation (52) the apparent resistance of the coil circuit is increased or reduced by permitting the core currents to flow, according as

$$Ln/R<\text{or}>\frac{\cdot 396}{\cdot 910}=\cdot 42.$$

By our initial supposition, we have $n=2\pi v=100\pi=314{\cdot}16$, therefore

$$L/R=\cdot 42/314{\cdot}16=\cdot 0013\text{ second}$$

is the critical value of the time constant of the coil circuit. Now, if the coil be short circuited, the value of the time constant can be far greater than this. For instance, by the formula for L/R given in the last example, L/R would be $\frac{1}{40}$ sec. if the depth of the coil were $\frac{2}{10}$ of its radius. It would then require a considerable resistance to be inserted in circuit with the coil to reduce the time-constant to ·0013 sec. If still more resistance be inserted, the core currents will weaken the coil current; if less, they will strengthen it. The amount of this strengthening when the coil has little external resistance in connection with it, we may see from equation (53) by taking therein $L/R=\cdot 025$ and $n=314{\cdot}16$. We get

$$\left(\frac{R_1}{R}\right)^2=1+5{\cdot}524+3{\cdot}108=9{\cdot}632=(3{\cdot}10)^2,$$

the coil current being therefore a little less than one-third of the strength it would have were there neither core currents nor self-induction. Now stop the core currents; we have

$$\left(\frac{R_1}{R}\right)^2=1+(7{\cdot}854)^2=(7{\cdot}86)^2\text{ say},$$

which makes the coil current a little over one-eighth of what it would be were there no self-induction as well. Thus, permitting the core currents increases the strength of the current in the coil about $2\frac{1}{2}$ times. (The magnetisation of the core, on the other hand, is much weakened, except near its boundary. At the boundary it is made $2\frac{1}{2}$ times as strong, but as above mentioned it has only 1/14 part of the boundary value at the centre; whereas, when the core currents are stopped, the value is sensibly the same throughout the core at any moment.)

The retardation ϵ of the coil currents behind the impressed force, which is given by $\tan\epsilon=Ln/R=7{\cdot}854$, or $\epsilon=82°40'$ when the core currents are stopped, is, by equation (54), brought down to

$$\tan\epsilon=7{\cdot}854/11{\cdot}376,\text{ or }\epsilon=35°$$

by letting the core currents flow.

We started with $y=40^2$, and the values of Y_1, etc., corresponding. That is, $4\pi\mu nr^2/\rho=40$. Consequently we may dig out from the same values of Y_1 etc., the results in a variety of other cases, varying the speed and the permeability, resistance and radius of the core in any manner consistent with $y=40^2$.

(TO BE CONTINUED.)

ON PHOTOMETRICAL STANDARDS.

By THOMAS T. P. BRUCE WARREN, Professor of Chemical Technology, Silvertown Institution.

It is probable that for some time to come we shall hear a great deal of the defects of the standard candle as a reference for the comparison of illuminated surfaces, and already several standards have been proposed which undoubtedly offer more reliable means of comparison than can possibly be obtained from candles, however carefully the wicks are prepared or the purity of the stearine secured.

It seems to me that, although a great deal has been written about this matter of standard illuminants, the main points have been overlooked—namely, the portability and simplicity of a standard source of light, and the production of reliably definite multiples of luminosity.

I think few people are prepared to contend that the standard candle fixed by Act of Parliament for the use of gas companies is sufficiently definite for a scientific purpose,

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although the idea may perhaps be commercially necessary, whatever means may be adopted in order to compare gas lights with the lights given by other methods of illuminating.

The light furnished by a standard candle or lamp giving even an illuminating power of 16 candles is too low for comparison with large electric lights; and while it is quite easy to compare small electric lights, such as the ordinary incandescent lamps, with a gas flame or lamp giving 16 candles, it is very difficult to make the comparison satisfactorily, even if a gas flame of 500 candle-power is to be adjusted against an arc light of 5,000 candles. And yet in many cases such an arc light has been compared with that of a single candle.

This difficulty arises partly, no doubt, from the difference in colour of the two lights. The explanation from the difference in colour does not seem to me quite satisfactory, because we do not experience any difficulty in measuring smaller electric lights against gas flames without the use of coloured glasses.

For comparing electric lights we require a definite standard easily and reliably reproduced, portable and capable of being produced in definite multiples of light power, and which must do away with the uncertainty due to the use of coloured glasses.

From a few experiments made in the laboratory of the Silvertown Institution I feel certain that we may look very hopefully for such a standard in the metal magnesium.

The light emitted by the burning of a piece of magnesium in the form of wire or ribbon can be compared with large electric arc lights without any of the difficulties being met with which surround the use of gas. We may say, too, that the colour of the two lights is very similar.

The intensity of the lights emitted when magnesium wires of different diameters are burnt varies as the weight consumed in a given time, so that by selecting wires of suitable diameter we can easily obtain a light equal to 50 or 5,000 candles without any cumbersome or costly apparatus or difficulty in the experimental operation itself.

I have proposed as the unit of illumination the light given out by a magnesium wire one millimetre diameter burning at the rate of one centimetre per second. This will correspond approximately to the combustion of the unit weight (one gramme) in 500 seconds. From a few roughly-made experiments such a light is equal to 8·25 standard candles.

For greater lights it is safer to use larger wires burning the same weight (one gramme), in that fraction of the above time obtained by dividing by the square of the diameter of the wire, so that the volatilisation of the wire may take place at about the same rate, by which any error due to this cause is avoided. The wire is not so liable to melt and go out, nor does it so easily oxidise as when smaller wires are more quickly burnt.

The advantages in favour of magnesium are that it can easily be obtained in wires of different diameters, and is not so liable to fluctuations as regards purity, &c., as other chemically prepared substances. So long as it is kept from oxidation it can be depended on for giving an uniform light when burnt at the same rate for the same size wire, and within certain limits the quantity of light emitted is directly proportional to the weight consumed in a given time.

So far as my experiments have gone it does not appear as if this means of comparison is accompanied with any of the difficulties due to oil, gas, or candles. A slight objection, which can no doubt be removed by a better form of lamp or holder, by which the wire or ribbon is fed, is that it appears necessary to burn only such lengths at a time that the variations due to the increased rate of combustion from the heated condition of the wire can be avoided.

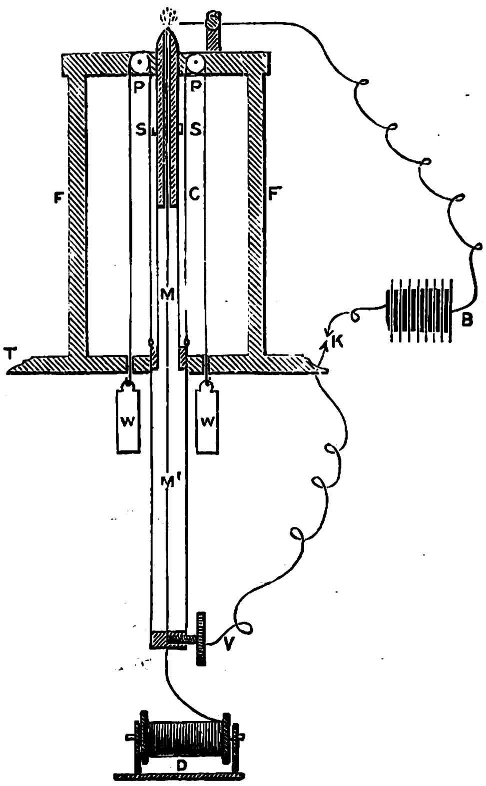
It is obvious that this source as a standard can be used in any photometrical arrangement, such as that of Bunsen or Rumford, and under conditions in which neither of these could be applied.

On a future occasion I hope to give the actual illuminating power due to the combustion of wires of different diameters and burning at different rates.

The simplest arrangement for fitting up a holder for the magnesium wire is to clamp a piece of a clay tobacco pipe stem in an ordinary burette clamp, and to feed up the wire by hand at the required rate. An automatic system to replace the latter renders the arrangement complete. The wire may be lighted by a match or by a spark from a battery or induction coil. The wire projecting from the top of the pipe is bent over so as to make contact with a platinum tipped wire from the battery, the other wire from the battery being led to a key, which enables the operator to ignite the wire and to start the photometer clock at the same instant. The feed gear can be made to stop the clock as soon as the measured quantity of wire is burnt.

A convenient table could be drawn up showing the candle-power given out by different-sized wires burning at a fixed rate, say one metre per minute, when a greater or lesser rate of consumption could be corrected to the required rate, as in ordinary photometrical calculations for gas, oil, or candles.

The following simple contrivance admits of giving greater accuracy to the experimental determinations of the time integral:—F is a frame made of wood supported on the table T. M is a brass tube carrying at its upper end a clay tube, C. The length of M and C together may be about 4ft. M′ is a slightly wider tube sliding with slight friction so as to enclose



M and C as far as the stops S S. The lower end of M′ is closed with a metal plug having a hole just large enough to admit the wire freely, which is then secured by a screw, V. To the upper end of the tube M′ are attached two cords passing over the pulleys P P fixed to the frame F, and carrying two weights W W, which in their descent draw M′ upwards, and with it the wire. The weights are adjusted so as to draw the tube up as fast as the wire is burnt. The stops are formed best of a rubber ring or washer, which can be moved along the tube M or C so as to arrest the upward motion of M as soon as the required length of the wire is burnt. D is a bobbin of wire from which the supply is drawn. A contact key is inserted at K. B is a battery for lighting the wire.

In all photometrical apparatus the parts necessary for the determination of the initial candle-power are always very costly, and I have no doubt that this fact has acted as a serious barrier in accurate electric light measurements. These considerations are removed by the new standard now proposed. An accurate measure of length can easily be made, so that having once fixed on the candle-power of a given-sized magnesium wire when burning, it will only be necessary to apply numerical corrections for the rate of burning.

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RELATION BETWEEN A CURRENT OF ELECTRICITY AND THE CONDUCTOR CONVEYING IT.*

BY THOMAS H. BLAKESLEY.

TABLE A (COMPILED FROM PRICE LIST OF MESSRS. SIEMENS BROS.).

Yards giving $\frac{1}{10}$ ohm resist.	Number of wires.	Area. A	Virtual dia. $= \sqrt{\frac{4A}{\pi}}$ d	a.	91·783 × A.	b.	$\overline{b - a}$.	·23 + 11·4d.	·23 + 11·4d + 91·783A.	c.	$\overline{c - a}$.	1·14 + 13d.	1·14 + 13d + 91·783A.
100	7	·026	·182	2·5	2·39	4·75	2·25	2·30	4·69	6.	3·5	3·5	5·89
200	14	·052	·257	4·75	4·77	8·	3·25	3·16	7·93	9·5	4·75	4·48	9·25
275	19	·0715	·302	6·5	6·56	10·	3·5	3·67	10·23	11·5	5·	5·07	11·63
535	37	·1391	·421	12·5	12·77	18·	5·5	5·13	17·90	19·5	7·	6·61	19·38
880	61	·2288	·540	21·	21·	27·	6·	6·38	27·38	29·	8·	8·16	29·16

d.	$\overline{d - a}$.	·4 + 8·934d + 21·186 A.	·4 + 8·934d + 112·969A.	e.	$\overline{e - a}$.	1·66 + 11·181d + 18·895A.	1·66 + 11·181d + 110·678A.	f.	$\overline{f - a}$.	3·25 + 12·143d + 22·069A.	3·25 + 12·143d + 113·852A.
5·	2·5	2·57	4·96	6·5	4·	4·19	6·58	8·5	6·	6·03	8·42
8·75	4·	3·80	8·57	10·50	5·75	5·52	10·29	12·50	7·75	7·52	12·29
10·75	4·25	4·61	11·17	12·50	6·	6·38	12·94	14·75	8·25	8·49	15·05
19·5	7·	7·11	19·88	21·50	9·	8·99	21·76	24·	11·5	11·43	24·20
31·	10·	10·07	31·07	33·	12·	12·02	33·02	36·	15·	14·86	35·85

At a meeting of the Society of Telegraph Engineers and Electricians on December 13th, 1883, I put forward in the course of the discussion, and in a general form, the grounds for dissenting from the views generally held, or at least expressed, as to the applicability of Sir Wm. Thomson's law of economy in conductors to cases to which that philosopher would certainly never have applied it. Neither time nor the power of memory allowed me to do more than treat the subject most generally; but the importance as regards the outlay of money and loss of energy can only be thoroughly appreciated by giving values to symbols and going practically into the results. This I propose doing in the present communication

The dogmatic forms given to the law of economy are the two following:—

1. The area of cross-section of the conductor is proportional to the current it has to carry.

2. The interest on the whole outlay in installing the conductor is equal to the value of the energy absorbed.

These two forms are different ways of expressing the same idea, and the one is true or untrue in the cases when the other is true or untrue, as will be shown.

Let C be the current required to be carried by.

„ r = the resistance of 100 yards of conductor, of cross-section 1 square inch.

„ y = the cost of one horse-power electric maintained for one year.

„ t = the proportion of entire time employed.

„ x = rate of interest on money laid out in installing the conductor, together with sinking fund required annually to maintain the installation in working order, per centum of the original cost.

„ A = the area of cross-section of conductor in square inches.

Further, let the whole expense of the conductor and its installation be dependent on its cross-sectional area in a way represented by a series of terms involving any powers of that area, not omitting the zero power which will occur in a constant term, as follows:—

$$a + bA + cA^m + dA^n + \text{etc.}$$

Here a is a constant term; bA is a term varying as the cross-section of conductor; $c\,A^m$, $d\,A^n$, etc., are any other terms involving any other powers of A.

The value of the interest and depreciation on this sum is equal to

$$\frac{x}{100}\left\{a + bA + cA^m + dA^n \text{ etc.}\right\}$$

The power expended is $\frac{C^2 r}{A}$ in watts. But one watt costs $\frac{y}{746}$ when maintained for a year; therefore the power employed would cost $\frac{C^2 r}{A} \cdot \frac{y}{746}$, if employed during the whole year. But when the fraction of the year the current flows is only t, the cost per annum will be $\frac{C^2 r}{A} \cdot \frac{y}{746} \cdot t$. Therefore the total cost in energy absorbed and conductor installed and maintained per annum is

$$\frac{C^2 ryt}{A\,746} + \frac{x}{100}\left\{a + bA + cA^m + dA^n \;\ldots\right\}$$

Now this form generally admits of a minimum, found by differentiating it with regard to A, and equating the result to zero. Thus

$$-\frac{C^2 ryt}{A^2\,746} + \frac{x}{100}\left\{b + cmA^{m-1} + dnA^{n-1} + \ldots\right\} = o.$$

Multiplying through by the quantity A, and transfering terms,

$$\frac{C^2 ryt}{A\,746} = \frac{x}{100}\left\{bA + cmA^m + dnA^n + \ldots\right\} \quad \ldots \quad \alpha$$

$$= \frac{x}{100}\left\{a + bA + cA^m + dA^n + \ldots\right\}$$

$$+ \frac{x}{100}\left\{-a + \overline{m-1}\,cA^m + \overline{n-1}\,dA^n + \ldots\right\} \ldots \beta$$

The term on the left is equal to the cost of the energy absorbed, and the first series on the right is the annual cost of installing and maintaining the conductor, and these two cannot be equal to one another except when the second series on the right is equal to zero.

This occurs when $a = 0$, $m = 1$, $n = 1$, &c., *i.e.*, when there is no absolute term as a, and no power of A involved in the con-

* Paper read at the Society of Telegraph Engineers and of Electricians, after Prof. Forbes' paper.

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ductor but the first power; and when this is the case the equation a shows that C^2 varies with A^2, for then $\frac{C^2}{A^2}$ is constant, or $\frac{C}{A}$ is constant, and the area is proportional to the current it has to carry. But when the first power is involved alone in the expense of the conductor, the meaning is that the cost is proportional to the area. Now I propose to show, first, that in an insulated conductor in the form of a cable, the expense of the conductor is not proportional to the area of the cross section; and, secondly, to show that the price of the cable can be formulated very closely in terms of the cross section. And obviously, if we can do this satisfactorily, we have no difficulty in finding at once the economical current for a section by the foregoing rules.

To carry out these points I beg to draw attention to the Table A on page 106, compiled from the price list of Messrs. Siemens Brothers, of Charlton.

Each horizontal line refers to the same conductor, and the first column gives the number of yards making up the tenth of an ohm. These numbers are used as denominations for the particular conductors, and are of course assuming the wires are always of the same conductivity, proportional to the cross-section of the conductor.

The second column gives the number of wires in each conductor.

The third gives the area of cross-section in square inches, called A.

The fourth gives the vertical diameter, called d, deduced from the equation $d = \sqrt{\frac{4A}{\pi}}$.

The fifth column gives the price of the bare conductor from the price list. It is marked a. The price is in pounds sterling per 100 yards run.

The next gives the result of applying a linear equation in A, viz., 91·783 A most nearly giving the actual price.

Then follow five series of four columns each.

Each series corresponds to a specification of the covering of the conductor, as follows:—

- *b.* Insulated with india rubber and tape.
- *c.* Insulated with india rubber, jute, and tape.
- *d.* Insulated with gutta percha.
- *e.* Insulated with gutta percha, jute, and tape.
- *f.* Insulated with gutta percha, jute, and tape, and iron sheathed.

The first column of each series gives the price from the price list of the covered conductor in pounds sterling per 100 yards run.

The second column gives the difference between the preceding column and the price of the bare conductor, that is to say the price of the insulation.

The third column gives the price of this as deduced from the formula found to give the real prices most approximately.

The fourth column gives the results of the formula of insulation combined with that of the bare conductor.

I have attempted only to find linear equations in d and A to express these prices. Greater approximation could be obtained by more complex formulæ, but even with those I have employed an inspection will show very rarely, I think, a deviation of as much as five per cent. But even this is not to be found in the cases where the total sum is considered.

Now, whether we look at the formula or at the figures taken from the price list, it is clear that the cost of insulation largely deviates from proportionality to the cross-section of the conductors. Consider, for instance, the 1st and 5th row of the column marked $c - a$, the figures being 3·5 and 8 respectively. The conductors are in cross-section as 1 to 8·8, and if the insulation expense were assumed to be proportional to the conductors, taking the 3·5 as the basis, we ought to find the expense of the insulation of No. 880 in this case 3·5 × 8·8, or 30·8 pounds instead of only 8 pounds, which it is. Similarly with all the other insulation prices. Moreover, these insulation prices are not small compared with those of the conductors bare. In many cases they are greatly in excess. According to specification f, it costs six pounds to insulate a conductor costing only £2 10s.

If we accept the formula as a representation of the price of a cable, it is easy in any particular specification to give the value of the economical current for any required cross-section, and by constructing a curve of values to perform the opposite problem, *i.e.*, to find the proper cross-section for a given current, the other necessary data being of course also given. Or a table may be easily calculated, as in the following cases.

As an example, the following table gives the values of the currents corresponding to certain areas of cross-section under the following data. The specification is that corresponding to e—insulation of gutta percha, jute, and tape.

The conductivity of the copper is $\frac{95}{100}$ of copper, giving 1 ohm in 25 miles of 1″ section.

The time of working is 8 in the 24, or $t = \frac{1}{3}$.

The cost of an electrical horse-power maintained for a year is £10.

The rate of interest and depreciation together is 7·5 per cent.

Area in square inches.	Economical current in amperes.	Economical intensity or current ÷ area.
·01	11	1103
·04	40	999
·09	86·5	961
·16	150·7	942
·25	232	930
·36	332	922
·49	448·8	916
1·00	906	906

If the working hours were 12 in 24, instead of 8 in 24, the numbers in the second and third columns of the table would have to be reduced in the proportion of $\sqrt{3} : \sqrt{2}$, *i.e.*, multiplied by the fraction ·816.

The formula corresponding to the above case is

$$\frac{C^2}{A^2} = 44259{\cdot}2 \left\{ \frac{1}{\sqrt{A}} + 17{\cdot}545 \right\}$$

The following table relates to specification b, but otherwise the same data are used:—

Area in square inches.	Current in amperes.	Intensity or current ÷ area.
·01	10·5	1046
·04	37·28	932
·09	80·19	891
·16	139·2	870
·25	214·25	857
·36	305·28	848
·49	412·58	842
1·00	830	830

The formula is

$$\frac{C^2}{A^2} = 45126{\cdot}1 \left\{ \frac{1}{\sqrt{A}} + 14{\cdot}27 \right\}$$

Similarly tables and curves can be formed whenever it is possible to formulate the price of the cable.

It is hoped that these cases have sufficiently indicated the method to be followed generally.

Here it may be well to reflect what a great advantage it would be for the general purposes of design if manufacturers were to make a practice of supplying prices in a formulated shape. It is presumed that they all have their modes of calculation, and it seems easy to throw the expression of their results into an algebraical form.

The above results have been deduced from a single price list, and it may be the prices are somewhat high. No allowance, too, has been made for discount, which would have the effect of diminishing the intensity of the economical current in half the ratio of the discount. But enough has perhaps been said to show the fallacy of the ordinary modes of quoting the economical law of Sir William Thomson, and assigning a fixed value to the current density.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes	97
Electro-Chemistry. By Dr. G. Gore. (Continued)	102
The Induction of Currents in Cores. By Oliver Heaviside. (Continued)	103
On Photometrical Standards. By T. T. P. Bruce Warren. Illustrated	105
Relation Between a Current of Electricity and the Conductor Conveying It. By T. H. Blakesley	106
Electric Currents and the Human Body	108
Correspondence	109
New Spring for Measuring Instruments. By Profs. Ayrton and Perry. (Concluded.) Illustrated.	109
Thunderstorms. By Professor Tait. Illustrated	114
Installation of the B.T.K. System of Electric Lighting at Colchester. Illustrated	117
Companies' Share List	120

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IMPORTANT NOTICE.

⁎ All communications should be sent to our new offices, 1, Salisbury-court, Fleet-street, E.C., where *The Electrician* is now printed and published.

ANSWER TO CORRESPONDENT.

G. K.—*Under old Act drawings must be 12 inches by 8½ inches or 12 inches by 17 inches, leaving a margin of 1 inch on every side of the sheet.*

LETTERS.—*Several letters for* "ALPHA" *and one for* "ACCUMULATOR" *are at this office.*

ELECTRIC CURRENTS AND THE HUMAN BODY.

Dr. Stone's letter, which will be found in another column, asking for particulars of facts relating to the effects of electrical currents on the human body will, we have no doubt, revive the interest which that gentleman was the first to arouse in a subject of no small importance to electrical research. The paper read by Drs. W. H. Stone and W. J. Kilner before the Society of Telegraph Engineers in March, 1882, a report of which will be found in our issue of the 18th of that month, gave an account of what were, we believe, the first serious attempts made in this country to investigate the subject of electrical therapeutics. Ever since that time Dr. Stone has been devoting attention to this matter, and he will probably give the world the benefit of his subsequent experience in a paper shortly to be read at the International Health Exhibition. There is one class of phenomena, however, beyond the domain of the experimenter, namely, the effect on the human body of electrical currents fatal or dangerous to life. Dr. Stone therefore asks for information as to the observed facts where accident has furnished what experiment may not seek. From the time of the famous Russian philosopher who gained a place among the martyrs of science by losing his life while attracting electricity from the clouds, down to the present era of electric lighting and electrical transmission of power there have been a vast number of casualties, the unavoidable consequences of dealing with a force the effects of which were only imperfectly understood. More especially has this been the case since the introduction of electric lighting, the diminution of such accidents, however, of late showing that the chief danger arose from our ignorance of its character. How extremely ignorant we still are on this point is shown in the circumstance that whenever anybody is killed or maimed by electrical shock there is always somebody else ready to declare that he has submitted himself to precisely similar conditions without feeling any ill effects. The proprietors of powerful dynamos almost ask us to believe that electrical currents are only dangerous to persons of inferior education, and that when a man has undergone a course of scientific training the powers of death are mollified in compliment to his superiority. Dr. Stone of course does not believe this, and he asks for the truth with regard to all accidents of the kind, whether fatal or only serious, due to the passage of electrical currents through the human body. The chief facts required by him are, as to the strength of the current, whether constant or alternating, and the interval that elapsed, if any, between the shock and the death of the victim.

This is what Dr. Stone asks for, and we invite our readers engaged in the business of applied electricity to furnish him with all the information in their power. Although not explicitly referred to by Dr. Stone, cases of death by lightning, when the facts are well authenticated, would no doubt be of service to him—that is to say, the physical effects observed in cases of fatal accident through stroke of lightning. It would be too much to expect that any particulars as to the temperament and constitution of the victim can be given; but these, we presume, are by no means unimportant data, and in future observations it may be hoped they will be noted. We speak under correction of a medical authority like Dr. Stone, but we imagine that suddenness, or rather unexpectedness, constitutes one chief element of danger from electric shock. There are of course currents of electricity that not only extinguish vitality, but would wreck the body were it twenty times stronger than it really is; but there are others which, we fancy, cause death simply by blow to the nervous system. We have all experienced shocks which have distressed us considerably, and many people have voluntarily submitted to what, if they had received it unawares, might have killed them. It is here that the element of temperament comes in, and it is probable that a good many deaths attributed to the effects of electrical current are really due to something closely akin to the effect of fright.

Making allowance for these cases, however, there are no doubt many in which the bodily effect of the current has left traces sufficient to mark the true cause of death, and it is these which would prove most helpful to the investigation Dr. Stone has in hand. At the meeting of the Society of Telegraph Engineers already referred to, Dr. Stone, although ridiculing the pretensions of the vendors of electrical appliances for curative purposes, acknowledged that some useful results—or at all events encouraging results—had been obtained by the application of currents of electricity in certain cases of disease. The members who attend the forthcoming gathering of the Society at the Health Exhibition will be curious to learn whether these encouraging results have been borne out by further tests at the hospital with which Dr. Stone is connected. In the discussion which took place two years ago several points, as we remarked at the time, were either overlooked or misunderstood. Amongst these we may mention

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the unexplained fact of a current passing by the arms through the body being felt only at the places of contact with the conductors. With increase of strength the shock, or rather shocks, are felt farther away from the terminals, and when still stronger current is used—approaching to the dangerous point—the two sensations, for there are two, are felt near each other on either side of the chest. This is contrary to our practical experience of the equable flow of current through an ordinary conductor, and it would seem that either the human body differs from every other known form of galvanometer—if we may so call it—or else that the ordinary galvanometer fails to tell us something that really happens during the passage of currents through high resistances. The question arises, is sensation a true indicator of the reach of the efficient current? If so, then for therapeutic purposes the terminals must be placed close to the seat of disease, or the currents must be of increased strength. These are trifles, however, compared with the one essential question—What is the actual physical effect of the current apart from the sensation it occasions? At present it is like a medicine whose only known virtue is its nastiness.

CORRESPONDENCE.

ACCIDENTS FROM ELECTRICAL CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Would you kindly ask your readers to furnish me with information as to fatal or serious accidents from the passage of electrical currents through the human body? I write for this with a view to my proposed paper on behalf of the Society of Telegraph Engineers and Electricians at the Health Exhibition. The chief points to be noted are the strength and nature of the current, whether constant or alternating, and the rapidity of death. At least three modes of fatal injury seem possible under the conditions present, and it is important to discriminate between them. It would be convenient to send any replies to this address, viz., Society of Telegraph Engineers and Electricians, 4, The Sanctuary, S.W.—Yours, &c., W. H. STONE.

[We have called attention to Dr. Stone's request in our leading article.—ED. *E.*]

A NEW FORM OF SPRING FOR ELECTRIC AND OTHER MEASURING INSTRUMENTS.*

BY PROFESSORS W. E. AYRTON, F.R.S., AND JOHN PERRY, M.E.

(CONCLUDED FROM PAGE 89.)

Springs with a Rectangular Section.—For practical purposes it is obviously more convenient to use in the construction of our springs thin strips of a rectangular section rather than of an elliptic section. We have therefore now to consider how equations 13, 14, and 15 will be modified if our strip has a rectangular section, the longer side of the section being $2a$ and the shorter side $2b$. In this case

$$B = \tfrac{4}{3}ab^3E,$$

and since, as was discovered by M. Cauchy in 1829, the torsion rigidity of a rectangle bears to the torsional rigidity of an inscribed ellipse the proportion of their moments of inertia about a line drawn through the common centre perpendicular to their plane, in the case when one principal dimension is several times the other, it follows that

$$A = N\pi\frac{a^3b^3}{a^2+b^2} \times \frac{\frac{4}{3}ab^3}{\frac{\pi}{4}ab^3},$$

or

$$A = \tfrac{16}{3}N\frac{a^3b^3}{a^2+b^2}.$$

* Reprinted from the *Proceedings* of the Royal Society.

Hence

$$\phi = \frac{lFr\sin\alpha\cos\alpha}{4ab^3}\left(\frac{3}{4N}\frac{a^2+b^2}{a^2} - \frac{3}{E}\right),$$

$$d = \frac{lFr^2}{4ab^3}\left(\frac{3}{4N}\frac{a^2+b^2}{a^2}\cos^2\alpha + \frac{3}{E}\sin^2\alpha\right);$$

or, as b^2 is insignificant in comparison with a^2,

$$\phi = \frac{3lFr\sin\alpha\cos\alpha}{4ab^3}\left(\frac{1}{4N} - \frac{1}{E}\right) \quad . \; . \; . \; . \; . \; . \quad (16),$$

$$d = \frac{3lFr^2}{4ab^3}\left(\frac{\cos^2\alpha}{4N} + \frac{\sin^2\alpha}{E}\right) \quad . \; . \; . \; . \; . \; . \; . \quad (17).$$

We will now calculate the value of f, the maximum stress at any point in the rectangular section.

The shear stress at any point xy in such a section of the prism which has received a twist τ per unit of length is, where the axes of x and y are parallel to the edges of the section, and the origin the centre of the section, z being at right angles to the section,

$$N\left(\tau x + \frac{d\gamma}{dy}\right) \text{ in the directions of } y \text{ and } z,$$

and

$$N\left(-\tau y + \frac{d\gamma}{dx}\right) \text{ in the directions of } z \text{ and } x,$$

where γ equals $-\tau xy +$ an expression which vanishes if the thickness of the strip is very small.

Hence, since

$$\frac{d\gamma}{dy} = -\tau x,$$

and

$$\frac{d\gamma}{dx} = -\tau y,$$

it follows that the shear stress at a point xy is

0 in the direction of y,

and $-2N\tau y$ in direction of x,

so that the whole shear stress at a point is $-2N\tau y$, and the shear stress, q, at the middle of the longer edge of the rectangular section, where we may suppose the shear stress is the greatest, is $2N\tau b$.

Now if C is the twisting couple, we know that

$$\tau = \frac{C}{A},$$

hence

$$\tau = \frac{3Fr\cos\alpha}{16Na^3b^3}(a^2+b^2),$$

and

$$q = \frac{3Fr\cos\alpha}{8a^3b^2}(a^2+b^2).$$

Also, since $Fr\sin\alpha$ is the bending couple, the greatest stress due to bending,

$$p = \tfrac{3}{4}\frac{Fr\sin\alpha}{ab^2}.$$

Hence if f is the greatest total stress anywhere in a section, it may be shown that

$$f = \tfrac{3}{8}\frac{Fr}{ab^2}\left\{\sin\alpha + \sqrt{1 + \frac{b^2}{a^2}\cos^2\alpha\left(\frac{b^2}{a^2}+2\right)}\right\}.$$

Or, as a is very large in comparison with b,

$$f = \tfrac{3}{8}\frac{Fr}{ab^2}(1+\sin\alpha) \quad . \; . \; . \quad (18).$$

If, as is usual in the case of the springs we employ, the edges of the strip nearly touch one another in two consecutive coils, and the angle of the spiral is 45°, we have the area of the cylinder which the metal strip approximately covers, or $\frac{2\pi rl}{\sqrt{2}}$ equal to the area of the strip, or $2la$, so that

$$\frac{r}{a} = \frac{\sqrt{2}}{\pi},$$

and equations (16), (17), and (18) may be simplified thus

$$\phi \propto 0{\cdot}17\,\frac{lF}{b^3}\left(\frac{1}{4N}-\frac{1}{E}\right) \qquad (19).$$

$$d \propto 0{\cdot}17\,\frac{lFr}{b^3}\left(\frac{1}{4N}+\frac{1}{E}\right) \qquad (20).$$

$$f \propto 0{\cdot}29\,\frac{F}{b^2} \qquad (21).$$

Use of Spring to determine $\frac{E}{N}$.—Before proceeding to a description of the various measuring instruments in which we have applied this new form of spring, we may mention one interesting application of it to enable us to determine readily the ratio of the modulus of rigidity, N, to Young's modulus of elasticity, E, for any material. It is well known that the celebrated conclusion of MM. Navier and Poisson from Boscovich's molecular theory requires that the ratio of E to N should be

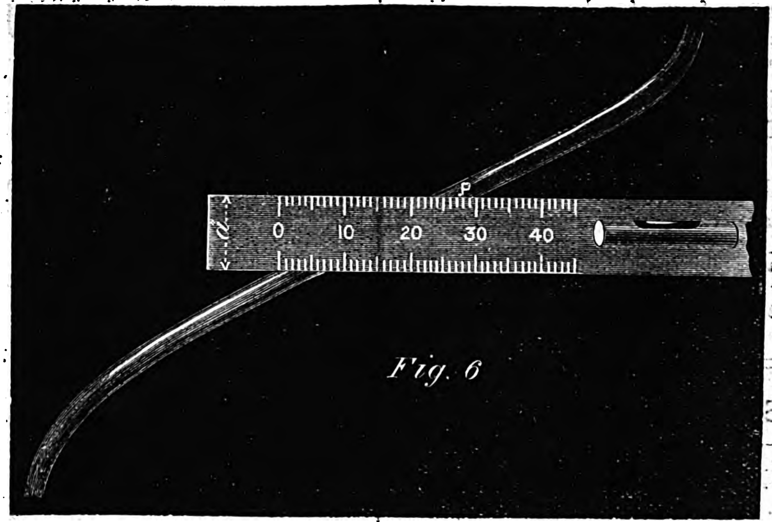

Fig. 6

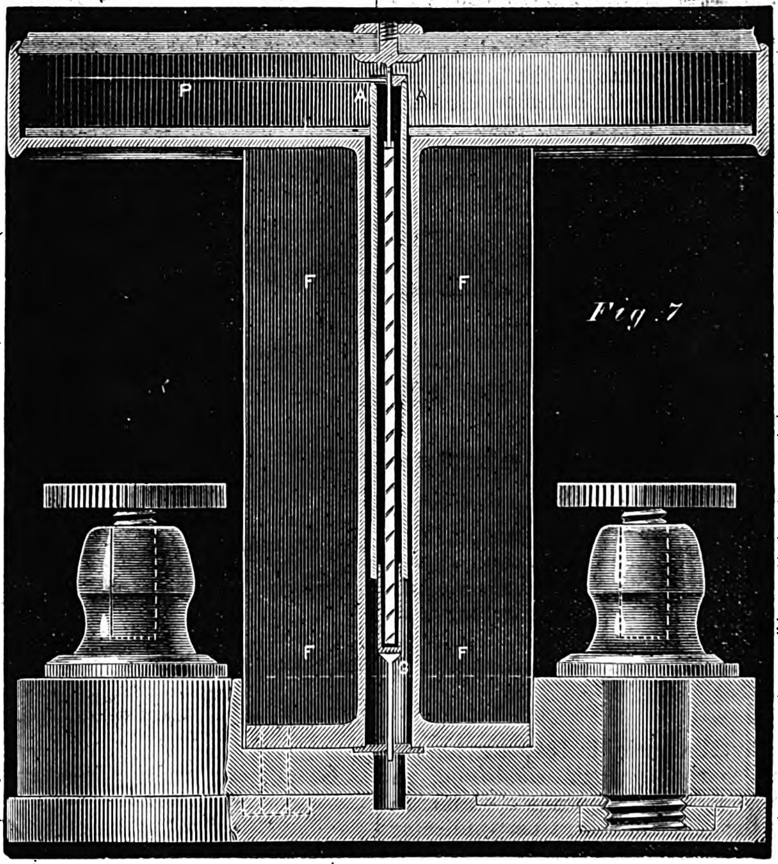

Fig. 7

We have preferred to say that ϕ, d, and f are respectively proportional rather than equal to the expressions on the right hand side, because when the strip is wide in comparison with the radius of the cylinder about which it is bent, the strip receives in addition to the bending and shear strains which we have considered a lateral bending also, and the exact effect of this we have not yet fully investigated.

2·5 for all solids. Professor Stokes showed that this conclusion was impossible if its authors supposed it to apply to jellies and to india rubber, and that it was probably untrue in the case of metals; and Wertheim, Kirchhoff, Thomson, Everett, and others have experimentally shown its untruth in the case of brass, iron, copper, and glass. In pursuance of the present investigation it has struck us that this ratio may be most con-

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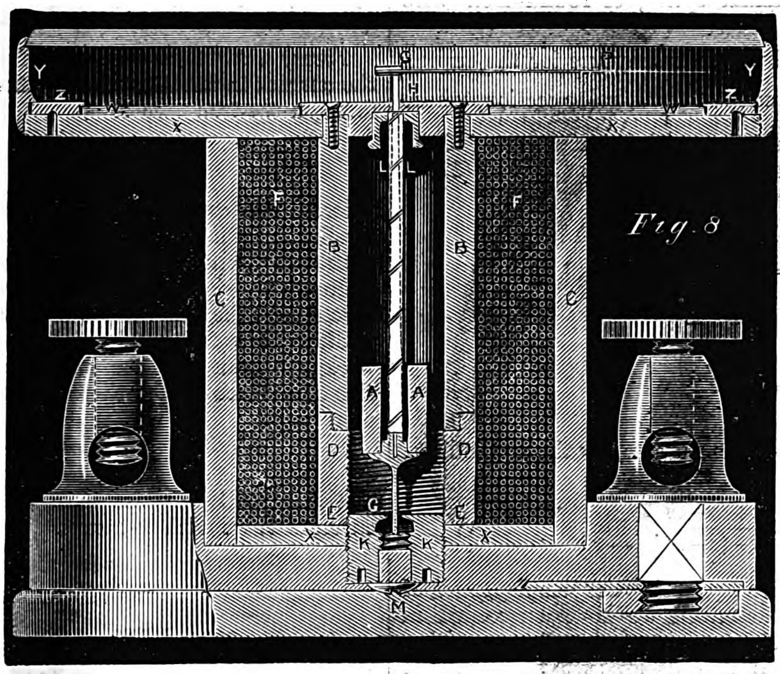
veniently determined by the use of our springs from one experiment.

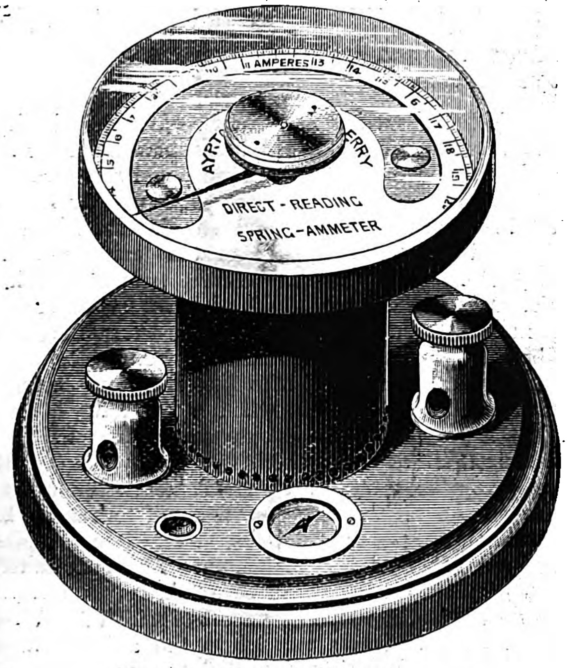
When the spring is made of round wire, so that a and b are equal to one another, we have from equation (11)

$$\frac{r\phi}{d} = \tan a \frac{\frac{E}{N} - 2}{\frac{E}{N} + 2 \tan^2 a};$$

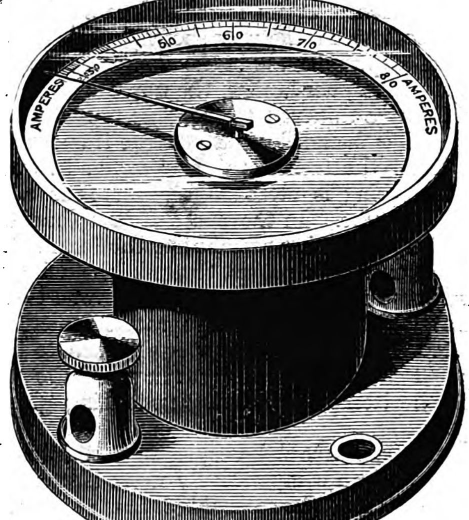
wire is observed in its position in the upper scale, the reading being b. Now the spring is elongated by an axial force until the point P comes opposite a point on the lower scale, and the reading is now c. As the two scales are similar and parallel to one another, and as a spirit-level has been employed to make the scales horizontal, it is obvious that as the axis is vertical

$$\frac{a}{c-b} = \frac{d}{r\phi} = \tan \beta,$$





Direct Reading Spring Ammeter.



Shielded Instrument.

let $\frac{r\phi}{d}$ be called cot β, then it can be shown that

$$\frac{E}{N} = -2 \tan a \tan (a + \beta),$$

so that if a is 45°

$$\frac{E}{N} = \frac{\tan \beta + 1}{\tan \beta - 1} \quad \text{. . . . . . (22).}$$

In order to measure tan β most conveniently, we may employ (Fig. 6) a pair of cylindric scales, the distance apart of which, close to the wire of the spring is a inches. A point, P, on the

so that

$$\frac{E}{N} = 2\frac{a + (c-b)}{a - (c-b)}.$$

We have used three springs made from round wire respectively of brass, iron, and steel for the sake of illustration. In all of them we find that $c - b$ is small in comparison with a, so that roughly we may say that the excess of $\frac{E}{N}$ over 2 is $\frac{(4c-b)}{a}$, that is, is proportional to $(c - b)$. The cylindrical scale has only been introduced for the sake of illus-

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tration. For an accurate determination of $\frac{E}{N}$ a telescope would be employed having a motion about the axis of the spring, and also a motion parallel to the axis, and by means of which the motion of a point on centre line of the wire when an axial force is employed would be accurately observed. It is sufficient to say that the brass spring of round wire exhibited to the Society gives a value of $\frac{E}{N}$, which is 8 per cent. less than the value given by the similar spring of round iron wire exhibited.

Instead of using a round wire, we may use for the experimental determination of $\frac{E}{N}$ a strip of rectangular section, whose breadth is very great in comparison with its thickness. If the angle of the spiral is 45°, then from equations (16) and (17) it follows that

$$\frac{\phi r}{d} = \frac{\frac{1}{4N} - \frac{1}{E}}{\frac{1}{4N} + \frac{1}{E}},$$

$$\frac{E}{N} = 4\frac{d + \phi r}{d - \phi r};$$

therefore measuring ϕr as $c - b$, and d as a, by the method just described, we have

$$\frac{E}{N} = 4\frac{a + (c - b)}{a - (c - b)}.$$

Some Practical Uses of the Springs.—By the employment of springs such as we have described we have succeeded in making *ammeters* and *voltmeters*, or instruments for measuring respectively electric currents and differences of potential, in which the pointer moves over in some cases as much as 270° of the scale instead of only 50°, which is all that can be obtained with ordinary galvanometers. One form of the instrument is shown in Fig. 7, where AA is a thin hollow tube of charcoal iron attached at its lower end to a brass piece, G, guided at the bottom in the way shown. To G is attached the lower end of a spring made in the way we have described of silver or hard phosphor-bronze, the upper end of which is attached rigidly by a thin rod to the glass top of the instrument, which itself is fastened rigidly to the framework of the instrument. The rod attached to the glass, and to which the upper end of the spring is attached, also serves as a guide to the top of the iron tube. In the space FF a solenoid wire or strip is wound, its ends being attached to the terminals shown. Hence, when a current is passed through the wire, the iron tube is sucked into the solenoid, and its lower end G, to which the spring is attached, receives a large rotatory motion, which is communicated directly to the pointer attached to the top of the iron tube. Parallax in taking readings of the pointer is avoided by the horizontal scale being on looking glass in the well-known way.

By making the iron tube AA very thin, so that it is magnetically saturated for a comparatively weak current, by fixing it so that it projects into the solenoid a fixed distance which has been carefully determined by experiment, and by constructing the spring in conformity with the conditions worked out in this paper, so as to obtain a large rotation with minimum stress, and with not too much axial motion of the free end of the spring, we have succeeded in obtaining deflections up to 270° directly proportional to the current, and without any permanent set being given to the spring.

To prevent a spring taking a permanent set for a large deflection, it is of great importance that the spring after being delivered by the maker should receive a large degree of permanent set in the direction in which we wish it to be afterwards strained in ordinary working.

In spite of the fact that Professor J. Thomson in the *Cambridge and Dublin Math. Jour.*, November, 1848, explained the importance of initial strains in materials, the reason is not yet sufficiently well understood why when a round bar has been well twisted beyond the limit of permanent set in a certain direction it has twice as much elastic strength to resist torsion in this direction as in the opposite direction. Now in the very act of manufacturing our springs, that is in the bending of the strip, the material acquires strains which are just opposite in character to the initial strains which we wish it to possess, for, as already explained, if the spring be constructed as in Fig. 3, an extension of the spring produces a rotation tending to uncoil it. Hence a spring must not be regarded as ready for use until it receives a good set by means of a weight hung from its end.

Theory of the Solenoid Spring Ammeter or Voltmeter.—If C is the current in amperes flowing through the coil, the attractive force on the iron core is

$$\frac{KC^2}{1 + SC},$$

where S is a constant, which is the greater as the current is smaller for which the iron tube AA, Fig. 7, becomes saturated with magnetism. The position of this iron core in the solenoid is so selected that K remains practically constant throughout the small range of downward motion of the core.

Since the rotation ϕ has been produced by an axial force, we know, from the theory of the spring already given, that this axial force is $p\phi$, where p is some constant. Hence

$$p\phi = \frac{KC^2}{1 + SC},$$

and since SC is great in comparison with unity for such currents as we wish to measure, we have

$$\frac{p\phi}{K} = \frac{C}{S} - \frac{1}{S^2},$$

or

$$C = \frac{Sp}{K}\phi + \frac{1}{S},$$

that is, equal divisions of the scale correspond with equal additions to the strength of the current except close to the zero, and we usually do not graduate these instruments within 5° of the zero.

Shielded Measuring Instruments.—When it is desired to use the instrument close to a dynamo machine or electro-motor in action, we have adopted a different and somewhat special form of construction, which is shown in Fig. 8, by means of which the instrument is to a great extent shielded from even powerful external magnetic fields. In this instrument the electro-magnet consists of a hollow core, part of which, BB, is of charcoal iron, and part, DE, of brass or other non-magnetic metal. The outside tube, CC, and the plates, XX, top and bottom, are also of charcoal iron. The space FF is filled with insulated wire in electrical connection with the terminal, so that when a current is sent through the instrument an intense magnetic field is formed between D and E, which are the poles of the electro-magnet. To the iron tube AA, also made of charcoal iron, the spiral spring, in this case made of extremely hard steel, is attached, the other end being attached to the piece F, which is fixed relatively to the bobbin. The spindle GG, which is fixed to the moving iron core AA, moves freely in bearings HH, so that the only movements of which A is capable are one of rotation and one parallel to the axis of the bobbin. As the iron core A projects into the strong magnetic field between D and E it is strongly attracted towards E when the current flows, and, as before, causes a large rotation of the pointer P over the scale. As a means of varying the power of the instrument an adjustable iron piece K is provided, which can be screwed nearer to or farther from the core A, and by the use of which the sensibility of the instrument can be adjusted so as to make the instrument "direct reading," that is to say, each division of the scale can be made to correspond with 1 ampere of current, or ·1 volt difference of potential, and the employment of a constant such as 1·34 ampere, or volt, per degree, which has hitherto been necessary with our measuring instruments, is now avoided. This power of adjustment produced by the use of the movable iron piece K, combined with the

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ease with which more or less wire can be wound on to the instrument, which also constitutes a second adjustment of sensibility, is of considerable importance, since the employment of a constant has not only led to error and delay in measurements made in electric light factories, but has caused the breakage of the pointer or the destruction of an instrument from a far too powerful current being sent through it by an observer (often a man with little experience in the employment of instruments) having confounded the constant of some other instrument with that of the one he was using.

The steel strip used in the construction of the spring for these shielded instruments is 0·0017 inch thick, and in a book just published on "Steel and Iron," by Mr. Greenwood, he mentions that some specimens of remarkably thin steel, $\frac{1}{110}$ of an inch, were shown in the Paris Exhibition, so that steel we are using is nearly as thin as that referred to by Mr. Greenwood. But within the last few days we have received from Mr. Charles Jowitt, of Sheffield, a specimen of steel rolled for us only just over 0·001in. in thickness, which is perhaps the thinnest steel yet made.

We have to thank one of our assistants, Mr. Bower, for so earnestly carrying out a long series of experiments on these very delicate springs.

Weighing Machines.—Another class of instruments in which we have practically employed this spring are weighing machines, and Fig. 9 shows one of the arrangements we adopt. The scale pan is prevented from turning by the part A B being square and fitting very loosely a square hole in C. This arrangement introduces practically no friction, and prevents the moment of inertia of the scale-pan and load interfering, by means of a rotatory motion, with the rapidity with which the pointer comes to rest when a load is put into the pan. The position of the pointer P, which revolves when a weight is placed in the scale-pan, is read off upon the spiral scale, D, which, in this specimen, we have graduated in pounds. In another of these weighing machines, shown in Fig. 10, the

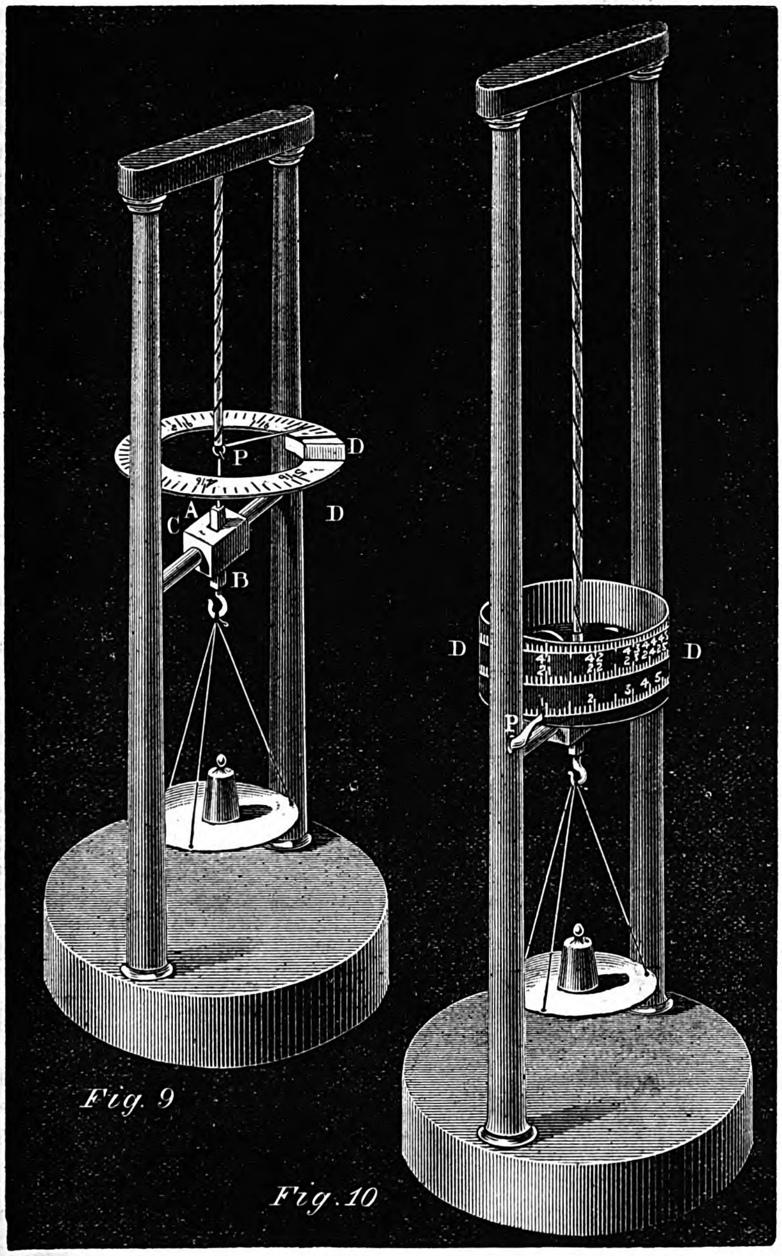

Fig. 9

Fig. 10

arrangement is the same with the exception that a cylindric scale, D, is fixed to the end of the spring and turns with it; the pointer P fixed on the frame of the instrument points to an indication of the weight on a spiral line drawn on the cylinder D. This second arrangement allows us to employ springs whose ends have a relative motion of five or six revolutions.

We have also made certain weighing machines where the weight is placed on a pan resting on the top of a rod passing up through the spring, and attached to the bottom of the spring, but hitherto we have found that this arrangement introduces too much friction.

When a very long spring is required for any purpose, and

where the weight of the spring itself would cause greater stresses on the upper part than on the lower part of the spring, it is our custom to let the breadth and thickness of the strip of material remain unaltered, but to let the diameter of the coils diminish towards the upper parts. The formulæ already given suffice to show how this may be done so as to obtain uniformity of maximum stress at all sections.

We also present before the Society a model showing a combination of bifilar and spiral spring suspension, in which great rotation and small axial lengthening or shortening are produced by an axial force.

THUNDERSTORMS.

BY PROFESSOR TAIT, F.R.S.

[At the commencement of this year Professor Tait delivered two lectures on the above subject at the Philosophical Institution, Edinburgh. The basis of these lectures is found in the lectures delivered at Glasgow in 1880, which Professor Tait has kindly annotated and permits us to use.—ED. *E.*]

A few years ago no qualified physicist would have ventured an opinion as to the nature of electricity. Magnetism had been (to a certain extent, at least) cleared up by an assumption that it depended on electric currents; and from Œrsted and Ampère to Faraday and Thomson, a host of brilliant experimenters and mathematicians had grouped together in mutual interdependence the various branches of electro-dynamics. But still the fundamental question remained unsolved, *What is Electricity?* I remember Sir W. Thomson, 18 years ago, saying to me, "Tell me what electricity is, and I'll tell you everything else." Well, strange as it may appear to you, I may now call upon him to fulfil his promise. And for good reason, as you shall see.

Science and Scotland have lately lost in Clerk-Maxwell one of their greatest sons. He was, however, much better known to science than to Scotland. In scientific ranks true merit is almost always certain to be recognised—in popular ranks modest merit scarcely ever is. His was both true and exceptionally modest merit. One grand object which he kept before him through his whole scientific life was to reduce electric and magnetic phenomena to mere stresses and motions of the ethereal jelly. And there can be little doubt that he has securely laid the foundation of an electric theory—like the undulatory theory of light admirably simple in its fundamental assumptions, but, like it, requiring for its full development the utmost resources of mathematical analysis. It cannot but seem strange to the majority of you to be told that we know probably as much about the secret mechanism of electricity as we do about that of light, and that it is more than exceedingly probable that a ray of light is propagated by electric and electro-magnetic disturbances. It can be but a small minority of you who have been at college so recently as to have been taught this. Yet, from the purely scientific point of view, it is one of the most remarkable advances made during this century.

But to know what electricity is, in the same sense as we may be said to know what light is, does not necessarily guide us in the least degree to a notion of its source in any particular instance. What, for example, causes the luminosity of fireflies, glowworms, &c., among natural objects, and of phosphorescent watch-dials among artificial ones? The answer is not yet ready, though it may soon come. So we might know quite well *what* is electricity and yet be, as I told you at starting *we are*, almost entirely uncertain of the exact source of *atmospheric* electricity.

To come to my special subject. I am not going to try to describe a thunderstorm. First, because I am certain that I could not do it without running the risk of overdoing it, and thus become sensational instead of scientific; and secondly, because the phenomenon must be quite familiar, except perhaps in some of its more singular details, to every one of you.

Science has to deal with magnitudes which are very much larger or smaller than those which such words as huge, enormous, tiny, or minute are capable of expressing. And though an electric spark, even from our most powerful artificial sources, appears to the non-scientific trifling in comparison with a mile-long flash of lightning, the difference (huge, if you like to call it) is as nothing to others with which scientific men are constantly dealing. The nearest star is as much farther from us than is the sun, as the sun is farther from us than is London. The sun's distance is 93,000,000 of miles. If that distance be called enormous, and it certainly is so, what adjective have you for the star's distance? The particles of steam are as much less than a drop of water as an orange is less than the whole earth. How can you fitly characterise their smallness? Ordinary human language, and specially the more poetic forms of it, were devised to fit human feelings and emotions, and not for scientific purposes; for the imagination, not for the reason. As there is a limit alike to pleasure and to pain, so there is to wonder and astonishment; and with words expressive of something near these limits ordinary language rests content. A thoroughly scientific account of a thunderstorm, if it were possible to give one, would certainly be at once ridiculed as pedantic.

Let us therefore, instead of attempting to discuss the phenomenon as a whole, consider separately some of its more prominent features. And first of all, what are these features when we are *in* the thunderstorm?

By far the most striking, at least if the thunderstorm come on during the day, is the extraordinary darkness. Sometimes at midday in summer the darkness becomes comparable with that at midnight, and in another sense it much resembles midnight darkness, for it is very different in kind as well as intensity from that produced by the densest fog. Objects are distinctly visible through it at distances of many miles, whether when self-luminous or when instantaneously lit up by lightning. The darkness, then, is simply intense *shadow*, produced by the great thickness and great lateral extension of the cloud-masses overhead. This altogether unusual amount of cloud always forms a prominent feature in a great thunderstorm. We have thus obtained one very important clue to the origin of the phenomenon. In cases where the darkness is not so great, though the storm is visibly raging overhead, it is always observed either that we are not far from the edge of its area or, in rarer cases, that the lower cloud strata lie much higher than usual. These form, therefore, no exception to the general conclusion just given as to the abnormal amount of cloud present. Seen from a distance, the mass of cloud belonging to the storm usually presents a most peculiar appearance, quite unlike any other form of cloud. It seems to boil up, as it were, from below, and to extend through miles of vertical height. The estimated height of its lower surface above the ground varies within very wide limits. Saussure has seen it as much as three miles; and in one case noticed by De l'Isle it may have been as much as five miles. On the other hand, at Pondicherry and Manilla it is scarcely ever more than half a mile. Haidinger gives the full details of an extraordinary case, in which the thundercloud formed a stratum of only 25 feet thick, raised 30 yards above the ground. Yet two people were killed on this occasion. Other notable instances of a similar extreme character are recorded.

Careful experiment shows us that the air is scarcely ever free from electricity, even in the clearest weather. And even on specially fine days, when large separate cumuli are floating along, each as it comes near produces a marked effect on the electrometer. Andrews obtained by means of a kite, on a fine clear day, a steady decomposition of water by the electricity collected by a fine wire twisted round the string. Thanks to Sir W. Thomson, we can now observe atmospheric electricity in a most satisfactory manner. I will test, to show you the mode of proceeding, the air inside and outside the hall. [The experiment was shown, and the external air gave *negative* indications.]

On several occasions I have found it almost impossible, even by giving extreme directive force to the instrument by means of magnets, to measure the atmospheric potential with such an electrometer, and had recourse to the old electroscope, with specially long and thick gold-leaves. On February 26th, 1874, when the sleet and hail, dashing against the cupola of my class room, made so much noise as to completely interrupt my lecture, I connected that instrument with the water-dropper, and saw the gold-leaves discharge themselves against the sides every few seconds, sometimes with positive, sometimes, often immediately afterwards, with negative electricity. Such effects would have required for their production a battery of tens of thousands of cells. Yet there was neither lightning nor thunder, and the water was trickling from the can at the rate of only two and a half cubic inches per minute. Probably had there not been such a violent fall of sleet steadily discharging the clouds we should have had a severe thunderstorm. That this is no fancied explanation is evident from the fact that falling raindrops are often so strongly charged with electricity as to give a spark just before they touch the ground. On such occasions, when the fall occurs at night, the ground is feebly lit up. This "luminous rain," as it has been called, is a phenomena which has been over and over again seen by competent and trustworthy observers. In the *Comptes Rendus* for November, 1879, we read of the curious phenomenon of electrification of the observer's umbrella by a slight fall of snow, to such an extent that he could draw sparks from it with his finger.

In calm, clear weather the atmospheric charge is usually positive. This is very commonly attributed to evaporation of water, and I see no reason to doubt that the phenomena are closely connected. I will show you one of the experiments upon which the idea is based. I can take no other form of experiment than a somewhat violent one, as the effects of the more delicate ones could not easily or

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certainly be made visible to so large an audience. [A few drops of water were sprinkled on a heated crucible, insulated, and connected with the electrometer.]

There can be no doubt that, whatever be the hidden mechanism of this experiment, the steam has carried with it a strong charge of positive electricity, for it has left the rest of the apparatus with a strong negative charge. We might reverse the subject of measurement by connecting the electrometer with the escaping steam, but I omit it, to save time, and because we will now try that form of the experiment in another way. [High-pressure steam escaping from a little boiler was made to play upon an insulated conductor furnished with spikes, and connected with the electrometer, which then showed a strong positive charge.]

There are many substances which produce on evaporation far greater electric developments than water does, some of positive, others of negative, electricity. By far the most remarkable in this respect to which attention has yet been called is an aqueous solution of sulphate of copper. (*Proc.* R.S.E., 1852.) The smallest drop of this solution thrown on a hot dish gives an intense negative effect—so great, in fact, that it may be occasionally employed to charge a small Leyden jar. But this, like the smaller effect due to water under similar circumstances, is not yet completely explained.

The next striking features are the flashes of lightning, which at intervals light up the landscape with an intensity which must in the majority of cases far exceed that produced by the full moon. To the eye, indeed, the flash does not often appear to furnish more than the equivalent of average moonlight, but it must be remembered that it lasts for a period of time almost inconceivably short, and that the full effect of light on the eye is not produced until after the lapse of a considerable fraction of a second. Professor Swan has estimated this interval at about one-tenth of a second; and he has proved that the apparent intensity of illumination for shorter intervals is nearly proportional to the duration. (*Trans.* R.S.E., 1849.) I can illustrate this in a very simple manner. [Two beams of light were thrown upon the screen by reflection from mirrors, each of which was fixed *nearly* at right angles to an axis. When matters were so adjusted that the brightness of the two illuminated spots was the same, one mirror was made to rotate. The corresponding light spot described a circle about the other, and the brightness of its track became less the larger the circle in which it was made to revolve.] The lightning flash itself on this account, and for the farther reason that its whole apparent surface is exceedingly small, must be in some degree comparable with the sun in intrinsic brilliancy—though, of course, it cannot appear so. The fact that its duration is excessively short is easily verified in many ways, but most simply by observing a body in rapid motion. The spokes of the wheels of the most rapidly-moving carriage appear absolutely fixed when illuminated by its light alone. One can read by its light a printed page stuck on a disc revolving at great speed. But the most severe test is that of Sir Charles Wheatstone's revolving mirror. Seen by reflection in such a mirror, however fast it may be rotating, a flash of lightning is not perceptibly broadened, as it certainly would be if its duration were appreciable.

The apparatus which, in our laboratories, enables us to measure the time which light, moving at nearly 200,000 miles per second, takes to pass over a few feet, is *required* to prove to us that lightning is not absolutely instantaneous. Wheatstone has shown that it certainly lasts less than a millionth part of a second. Take this, along with Swan's datum, which I have just given you, and you see that the apparent brightness of the landscape, as lit up by a lightning flash, is *less than one hundred thousandth part* of what it would be were the lightning permanent. We have thus rough materials for instituting a comparison between the intrinsic brightness of lightning and of the sun, and it is well to notice that this exceedingly brief duration saves us from serious injury to the sight, if not from total blindness, which would certainly result from a near and powerful flash if it lasted for one-tenth of a second.

Transient in the extreme as the phenomenon is, we can still, in virtue of the duration of visual impressions, form a tolerably accurate conception of the form of a flash; and in recent times instantaneous processes of photography have given us permanent records of it. Some of these are given in *La Nature*, December, 1883. These, when compared with photographic records of ordinary electric sparks, bear out to the full the convictions at once forced by appearances on the old electricians, that a flash of lightning is merely a very large electric spark. The peculiar zigzag form, sometimes apparently almost doubling back on itself, the occasional bifurcations, and various other phenomena of a lightning flash, are all shown by the powerful sparks from an electric machine. [These sparks were exhibited directly; and then photographs, of which one is represented in the woodcut (Fig. 1), were exhibited.]

But the spectroscope has recently given us still more convincing evidence of their identity, if any such should be wanted. This is a point of great importance, but I have not now time to discuss it. Thus, though on a very small scale comparatively, we may study the phenomena of lightning at convenience in our laboratories.

We thus know by experiment that electricity chooses always the easiest route, the path of least resistance. Hence the danger of taking the otherwise most natural course of standing under a tree during a thunderstorm. The tree, especially when wet, is a much better conductor than the air, and is consequently not unlikely to be chosen by the discharge; but the human body is a conductor much superior to the tree, and therefore is chosen in preference so far as it reaches. The bifurcations of a flash can puzzle no one who is experimentally acquainted with electricity, but the zigzag form is not quite so easily explained. It is certainly destroyed, in the case of short sparks, by heating the air. [Photographs of sparks in hot and in cold air were exhibited. One of each kind is shown in the woodcut (Fig. 2). The smoother is that which passed through the hot air. The other passed through the cold air nearer the camera, and is therefore not quite in focus.]

FIG. 1.

Now heating in a tube or flame not only gets rid of motes and other combustible materials, but it also removes all traces of electrification from air. It is possible, then, that the zigzag form of a lightning flash may, in certain cases at least, be due to local electrification, which would have the same sort of effect as heat in rarefying the air and making it a better conductor.

A remark is made very commonly in thunderstorms which, if correct, is obviously inconsistent with what I have said as to the extremely short duration of a flash.

Even if we supposed the flash to be caused by a luminous body moving along, like the end of a burning stick whirled around in a dark room, it would pass with such extraordinary rapidity that the eye could not possibly follow its movements. Hence it is clear that when people say they *saw* a flash go upwards to the clouds from the ground, or downwards from the clouds to the ground, they must be mistaken. The origin of the mistake seems to be a *subjective* one—viz., that the central parts of the retina are more sensitive, by practice, than the rest, and therefore that the portion of the flash which is seen directly affects the brain sooner than the rest. Hence a spectator looking towards *either* end of a flash very naturally fancies that end to be its starting point.

Before I can go farther with this subject it is necessary that I should give some simple facts and illustrations connected with ordinary machine electricity. These will enable you to follow easily the slightly more difficult steps in this part of our subject which remain to be taken.

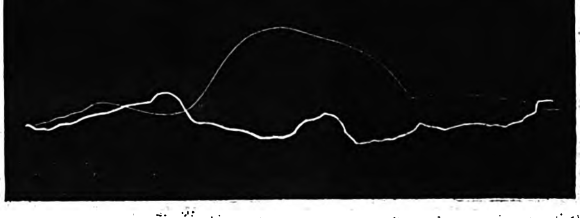

FIG. 2.

Since we are dealing mainly with *motion* of electricity, it is necessary to consider to what that motion is due. You all know that winds, *i.e.*, motions of the air, are due to differences of pressure.

If the pressure were everywhere the same at the same level we should have no winds. Similarly the cause of the motion of heat in a body is difference of temperature. When all parts of a body are at the same temperature there is no change of distribution of heat. Now electricity presents a precisely analogous case. It moves in consequence of difference of *potential*. Potential, in fact, plays, with regard to electricity, a part precisely analogous to the *rôle* of pressure, or of temperature, in the case of motions of fluids and of conducted heat. It would tax your patience too much were I to give an exact definition of potential in a lecture like this; but you may get a sufficiently approximate notion of it in a very simple way—again by analogy. Suppose I wished to specify the power of the pump used to compress air in an air-gun receiver. I

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should say it can produce a limiting pressure of 40 or 100 atmospheres, as the case may be. If you try to go any farther it leaks. This would be considered quite definite information. But, mark you, nothing is said as to the *capacity* of the receiver. When the pump has done its utmost, the receiver, be it large or small, contains air at the definite pressure of the 40 or 100 atmospheres which measure the power of the pump.

A longer time will be required for a more capacious receiver, but the ultimate pressure is the same in all. And when two receivers contain air at the same pressure you may open a communication between them, but no air will pass, however much they may differ in capacity. Similarly, you may measure the power of a flame or a furnace by the highest temperature it can produce. It will take a longer time to effect this the greater is the thermal capacity of the body to be heated; but when two bodies are at the same temperature no heat passes from one to the other. Similarly, the power of an electrical machine may be measured by the utmost potential it can give to a conductor. The greater the capacity of the conductor the longer time will be required for the machine to charge it; but no electricity passes between two conductors charged to the same potential. Hence the power of a machine is to be measured by using the simplest form of conductor, a sphere, and finding the utmost potential the machine can give it. It is easily shown that the potential of a solitary sphere is directly as the quantity of electricity, and inversely as the radius. Hence electricity is in equilibrium on two spheres connected by a long thin wire when the quantities of electricity on them are proportional—not to their surfaces, nor to their volumes, as you might imagine—to their radii. In other words, the capacity is proportional to the radius. This, however, is only true when there are no other conductors within a finite distance. When a sphere is surrounded by another concentric sphere, which is kept in metallic connection with the ground, its capacity is notably increased, and when the radii of the spheres are nearly equal the capacity of the inner one is directly as its surface, and inversely as the distance between the two spheres. Thus the capacity is increased in the ratio of the radius of one sphere to the difference of the radii of the two, and this ratio may easily be made very large. This is the principle upon which the Leyden jar depends.

We may usefully carry the analogy of the pump a good deal further. Supposing the piston to be fully pressed home every stroke, the amount of work spent, even if the whole be kept cool, on each stroke continually increases, so that about two and a half times as much work is required to charge the receiver to 40 atmospheres as to 20. The same holds with electricity. Each successive unit of the charge requires more work to force it in than did the preceding one, because the repulsion of all already in has to be overcome. It is found, in fact, that the work required to put in a charge is proportional to the square of the charge. Of course less work is required for a given charge the greater is the capacity of the receiver. Conversely, the damage which can be done by the discharge, being equal to the work required to produce the charge, is proportional to the square of the charge, and inversely to the capacity of the receiver. Or, what comes to the same thing, it is proportional to the square of the potential and to the capacity of the conductor directly. Thus a given quantity of electricity gives a greater shock the smaller the capacity of the conductor which contains it. And two conductors, charged to the same potential, give shocks proportional to their capacities. But in every case, a doubling of the charge, or a doubling of the potential, in any conductor, produces a fourfold shock.

The only other point I need notice is the nature of the distribution of electricity on a conductor. I say *on* a conductor, because it is entirely confined to the surface. The law is—it is always so arranged that its attractions or repulsions in various directions exactly balance one another at every point in the *substance* of the conductor. It is a most remarkable fact that this is always possible, and in every case in one way only. When the conductor is a single sphere the distribution is uniform. When it is elongated the quantity of electricity per square inch of its surface is greater at the ends that in the middle; and this disproportion is greater the greater is the ratio of the length to the transverse diameter. Hence on a very elongated body, terminating in a point, for instance, the electric density—that is, the quantity per square inch of surface—may be exceedingly great at the point while small everywhere else. Now, in proportion to the square of the electric density is the outward pressure of the electricity tending to escape by forcing a passage through the surrounding air. It appears from experiments on the small scale which we can make with an electrical machine, that the electric density requisite to force a passage through the air increases under given circumstances, at first approximately as the square root of the distance which has to be traversed, but afterwards much more slowly, so that it is probable that the potential required to give a mile long flash of lightning may not be of an order very much higher than that producible in our laboratories.

But from what I have said you will see at once that under similar circumstances an elongated body must have a great advantage over a rounded one in effecting a discharge of electricity. This is easily proved by trial. [The electric machine being in vigorous action, and giving a rapid series of sparks, a pointed rod connected with the ground was brought into the neighbourhood, and the sparks ceased at once.] In this simple experiment you see the whole theory and practical importance of a lightning conductor. But, as a warning, and by no means an unnecessary one, I shall vary the conditions a little and try again. [The pointed rod was now insulated, and produced no observable effect.] Thus you see the difference between a proper lightning-rod and one which is worse than useless, positively dangerous. There is another simple way in which I can destroy its usefulness—namely, by putting a little glass cap on the most important part of it, its point, and thus rendering impossible all the benefits it was originally calculated to bestow. [The pointed rod was again connected with the ground, but furnished with a little glass cap. It produced no effect till it was brought within four or five inches of one of the conductors of the machine, and then *sparks* passed to it.] You must be strangely well acquainted with the phases of human perversity if you can anticipate what I am now going to tell you, namely, that this massive glass cap, or *repeller*, as it was fondly called, was only a year or two ago taken off from the top of the lightning-rod employed to protect an important public building. [The repeller was exhibited. It resembled a very large soda-water bottle with a neck much wider than the usual form.] From the experiments you have just seen it must be evident to you that the two main requisites of an effective lightning-rod are that it should have a sharp point (or, better, a number of such points, lest one should be injured), and that it should be in excellent communication with the ground. When it possesses these, it does not require to be made of exceptionally great section; for its proper function is *not*, as is too commonly supposed, to parry a dangerous flash of lightning; it ought rather, by silent but continuous draining, to prevent any serious accumulation of electricity in a cloud near it. That it may effectually do this it must be thoroughly connected with the ground, or (if on a ship or lighthouse) with the sea. In towns this is easily done by connecting it with the water mains, at sea by using the copper sheathing of the the ship, or a metal plate of large surface fully immersed. Not long ago a protected tower was struck by lightning. No damage was done in the interior, but some cottages near its base were seriously injured. From a report on the subject of this accident it appears that the lower end of the lightning-rod was "jumped" several feet into the solid rock! Thus we see, in the words of Arago, how "False science is no less dangerous than complete ignorance, and that it *infallibly* leads to consequences which there is nothing to justify."

That the lightning-rod acts as a constant drain upon the charge of neighbouring clouds is at once proved when there is, accidentally or purposely, a slight gap in its continuity. This sometimes happens in ships, where the rod consists of separate strips of metal inlaid in each portion of the mast. If they are not accurately fitted together, a perfect torrent of sparks, almost resembling a continuous arc of light, is seen to pass between whenever a thunderstorm is in the neighbourhood.

I cannot pass from this subject without a remark upon the public as well as private duty of having lightning-rods in far greater abundance than we anywhere see them in this country. When of proper conducting power, properly pointed, properly connected with the ground and with every large mass of metal in a building, they afford absolute protection against ordinary lightning—every single case of apparent failure I have met with having been immediately traceable to the absence of one or other of these conditions. How great is their beneficial effect you may gather at once from what is recorded of Pietermaritzburg, viz., that till lightning-rods became common in that town it was constantly visited by thunderstorms at certain seasons. They still come as frequently as ever, but they cease to give lightning flashes whenever they reach the town, and they begin again to do so as soon as they have passed over it.

A knight of the olden time in full armour was probably as safe from the effects of a thunderstorm as if he had had a lightning-rod continually beside him; and one of the Roman emperors devised a perfectly secure retreat in a thunderstorm in the form of a subterraneous vault of iron. He was probably led to this by thinking of a mode of keeping out missiles, having no notion that a thin shell of soft copper would have been quite as effective as massive iron. But those emperors who, as Suetonious tells us, wore laurel crowns or sealskin robes, or descended into underground caves or cellars on the appearance of a thunderstorm, were not protected at all. Even in France, where special attention is paid to the protection of buildings from lightning, dangerous accidents have occurred where all proper precautions seemed to have been taken. But on more careful examination it was usually found that some one essential element was wanting. The most common danger seems to lie in fancying that a lightning-rod is necessarily properly connected with the earth if it dips into a mass of water. Far from it.

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A well-constructed reservoir full of water is *not* a good "earth" for a lightning-rod. The better the stonework and cement the less they are fitted for this special purpose, and great mischief has been done by forgetting this.

A few years ago the internal fittings of the lighthouse at Skerryvore were considerably damaged by lightning, although an excellent lightning-rod extended along the whole height of the tower. But a long copper stove-pipe, rising through the whole interior of the tower, and the massive metallic ladder rising from the ground to the lowest chamber, though with a considerable gap between them, offered less resistance than the rod, and the lower end of the ladder was nearer to the sea than was the pool on the reef into which the lightning-rod plunged. Hence the main disruptive discharge took place from the stove-pipe to the ladder, blowing the intervening door to pieces. The real difficulty in these situations, exposed to tremendous waves, lies in effecting a permanent communication between the lightning-rod and the sea. But when this is done the sea makes far the best of "earths,"

When a lightning-rod dircharges its function imperfectly, either from insufficient conducting power or because of some abnormally rapid production of electricity, a luminous brush or glow is seen near its point. This is what the sailors call St. Elmo's Fire, or Castor and Pollux. In the records of mountain climbing there are many instances of such discharges to the ends of the alpenstocks or other prominent pointed objects. One very remarkable case was observed in 1879 in Switzerland, where at dusk, during a thunderstorm, a whole forest was seen to become luminous just *before* each flash of lightning, and to become dark again at the instant of the discharge.

Perhaps the most striking of such narratives is one which I will read to you from the memoirs of the Physical and Literary Society, from which about a century ago sprang the *Royal Society of Edinburgh*. These essays are rare and curious, and the names of Maclaurin, James and Matthew Stewart, Whytt, and Monro appear among their authors.

The following observations on Thunder and Electricity, by Ebenezer McFait, M.D., show how, in the search for truth, men may unwittingly put themselves in the gravest danger :—

"The experiment proposed by Mr. Franklin to prove that lightning and the electrical fire are the same has often been repeated with success, both in England and abroad, so that the most noted electrical experiments have been performed by fire drawn from the clouds.

"Mr. Franklin also first discovered that sharp points attract and discharge the electrical matter most copiously; and from thence supposes that a very sharp-pointed rod, fixed to the extremity of the topmast of a ship, with a wire conducted down from the foot of the rod round one of the shrouds and over the ship's side into the sea, would silently lead off the electrical fire, and save the ship from thunder in hot countries; and that by a similar method buildings might be preserved.

"So useful a proposal deserves to be examined; variety of experiments may give hints for new improvements. For this reason the following observations are communicated, though not so complete as might be wished, being the result of one trial only.

"It seldom thunders in this northern clime. In June, 1752, there seemed to be some thunder at a distance from Edinburgh; but from the beginning of July to the beginning of October we had nothing almost but continual rains. The last summer was uncommonly warm and dry; and yet we had only a few claps of thunder at Edinburgh, one evening, and my attempts for making any of those experiments were entirely unsuccessful until Saturday night, September 15, when we had a very great storm.

"I used a round iron rod, two-tenths of an inch diameter, about 11ft. long, sharpened at one end; the other end was inserted in a glass tube, and that tube stood in a common glass bottle, which I held in my hand.

"I used also another rod about three feet long, sharpened in like manner at one end, which stood with the other end in a glass tube, which was stuck in the ground. I began upon the Calton Hill. The lightning and fire in the air abounded greatly, and yet it was some time before anything else appeared. At last some rain began to fall, and the air turned moister, then fire appeared upon the extremities of each of the rods in a small pretty blaze, very like the fire which is discharged from the point of a sword in the dark, when the person that holds it is electrified, and stands upon glass or resin; or like that which appears upon any sharp point when presented to an electrified gun barrel, but in greater quantity. I touched the long rod with my finger, but had no sparks from it. The short rod was accidentally taken out of its tube, and yet continued to burn and blaze as formerly. In like manner the flame continued upon the end of the long rod, though I took hold of it anywhere at pleasure above the glasses, until I moved my hand or finger along within a few inches of the flame; then it was attracted by my hand, and vanished.

"I went from the Calton Hill to the Castle Hill at the other end of the town, and in passing through the streets no fire appeared upon either of the rods; but almost immediately when I got clear of the houses upon the open hill the point of the longer iron rod took fire. In the dark I had lost the tube belonging to the shorter rod, and the point of it did not catch fire when the longer one was kindled. Perhaps I did not wait long enough for a proper trial, for I soon touched the flame upon the long rod with the sharp point of the short one, and then it also took flame, and continued burning as before without any further dependence upon the longer one.

"I held the shorter rod by the sharp end and approached the blunt end of it to the flame upon the point of the longer rod; then this blunt end caught the fire, and the flame upon the points of the two rods continued rather stronger than on the single one before, so long as I kept them in contact, and the fires within three or four inches of one another; but when I drew them farther asunder the flame upon the extremity of the blunt rod vanished. This happened as often as I tried it, and it is evident that in like manner I could have got the fire to fix upon the points of a great many rods, and so have had them all flaming together. Once or twice a flash of lightning seemed to dart directly against the point of the rod; then the fire, as I thought, expanded itself and united with the lightning, but it immediately began to shine again when the lightning was past.

"Though it rained much in time of these observations, yet the fire upon the ends of the rods did not go out until it became so heavy as if it were pouring down out of funnels.

"After this I went home for some time, resolving to come abroad again when the storm was more tolerable; but it continued to rain all night so violently that I was obliged, with regret, to leave several experiments to the chance of some future opportunity. For example, I suspected that the glass tubes had not been of great use on this occasion, and wanted to have tried whether I should have had the same appearances by using the rods alone, without any other apparatus. This is very probable, as also that the glasses, by being wet, allowed the electrical fire to flow off as it was attracted.

"I beg leave to add a few remarks relative to this subject. It would seem that experiments of this kind may be made without danger when the thunder is at a moderate distance. The lightning expands itself, as it flies, and by expansion loses its vigour. Perhaps there is one simple and easy way of protecting masts and spires from thunder, viz., to fix horizontally upon the highest parts of them a flat round piece of wood, of a foot diameter or more, in order to prevent those blazing fires from fixing upon them, and accumulating.

"This storm passed directly over Edinburgh, and came on from the south by west, as nearly as could be estimated. There was a great deal of lightning that night, above sixty miles to the westward, but no thunder heard. At Glasgow there was very much lightning, and a few distant faint claps of thunder. On the road from Belford or Berwick it lightened incessantly, but two claps of thunder only were heard, and those very faint, so that there is reason to think that the fire of this storm spread over the breadth of 130 miles at least. I wish I could also give some account where this thunder began, and how far it ran before it was extinguished.

(TO BE CONTINUED.)

INSTALLATION OF THE B.T.K. SYSTEM OF ELECTRIC LIGHTING AT COLCHESTER.

On Wednesday, the 11th inst., at the invitation of the South Eastern Brush Electric Light and Power Company, a large number of gentlemen interested in electric lighting operations, went to Colchester to see the system adopted for the house-to-house lighting which is being carried out by this Company. The system is known as the B.T.K. system, having been devised by Messrs. Beeman, Taylor, and King, engineers to the Company. Previous to visiting the central and other stations, a meeting was held at the town hall, at which the chairman of the Company, Sir Michael Kennedy, presided. At this meeting Mr. King read a paper which he had prepared, describing the work and apparatus at Colchester. Previous to the reading of this paper the chairman stated that, so far as he was aware, Colchester might claim to be the first town, at any rate in England, where a system of house-to-house lighting had been installed; and at any rate the system about to be described had, he knew, not been adopted elsewhere. Thus Colchester would in future claim the proud position of being first in the field. He spoke very highly of the manner in which the efforts of the Company had been seconded by the mayor and the local authorities of Colchester. Every possible aid had been rendered in the work, and much of the success was due to the assistance thus rendered. The chairman mentioned that amongst the visitors was a deputation from the Commissioners of Sewers, from London, as well as the mayors and other officials from various local authorities, amongst which might be mentioned Brighton and Dublin. It was also pointed out that the restrictions of the Board of Trade had been rigidly complied with. Mr. King, one of the electricians responsible for this system, then read the following paper. It may be

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well to say that the paper was illustrated by the actual apparatus used, some of which we described and illustrated in *The Electrician* of March 8, 1884. The paper of Mr. King was as follows :—

I endeavour to show that the principle of *centralisation* has been one of the stumbling blocks in the way of the practical development of electric lighting over large areas. One of the aims of the system which we have commenced to install in Colchester is *decentralisation* in the broadest sense of the word as far as regards the station from which the supply of electricity is given, and the other is to make the supply entirely independent of the moving machinery, so as to avoid the liability to sudden stoppages from any cause. A cursory examination of the problem of electric lighting direct from the dynamo machine will show that the maintenance of a standard electromotive force or pressure, with an allowance of, say, 5 or 6 per cent. variation when large currents, such as would be required for, say, 600 or 700 incandescent lamps, are driven along even moderate lengths of conducting cable, would entail the use of perfectly compounded dynamo machines, very costly conductors, and engines fitted with almost absolutely accurate or perfect governing gear, such as, I am sorry to say, have not yet been invented. I will briefly describe the machinery and apparatus concerned in the production, storage, and supply of electricity on the B. T. K. system, the distinctive features of which are the use of secondary batteries or accumulators placed in favourable positions for reducing the length and dimensions of conducting cables ; dynamo machines capable of generating electric currents of any high electromotive force or pressure, so as to charge a large number of these secondary batteries at one time, although situated at a long distance from the dynamo or generating station ; rocking switches—actuated by a special cell, being one of any set of secondary batteries, and called the master cell, which break the charging circuit when the operation of charging is completed, and which shunt the stored current (if I may be permitted to use such a term) on to the mains and service wires for the supply to consumers, and which at the same time converts the high electromotive force which existed during the charging process to the standard E.M.F. required by the lamps in use. For this purpose there are alternate sets of batteries and rocking switches, so that while one set of batteries is being charged the other set is in supply, and by the time the maximum current is required, say, in the evening, both sets of batteries will have been fully charged, and will therefore have been cut out of the charging circuit, and will be connected to the supply mains. This alteration of sets in charge and supply is made quite automatic, so as to require no attention to this part of the plant beyond an occasional inspection. The engine for driving the dynamo machines was built by Messrs. Davey, Paxman and Co., of Colchester, and is of 25 horse-power nominal, semi-portable type, is capable of exerting 90 horse-power when working at 133 revolutions per minute. It is connected by belting from the fly-wheel, which is 7ft. in diameter, to a 4ft. 6in. pulley on the countershaft, and from pulleys of 5ft. diameter on the countershaft, by belting, to two No. 8 Brush dynamo machines. These are the largest machines of this type at present made, but a demand for machines giving twice the current at the same or a higher E.M.F. will no doubt be met as required. The machines at present in use give a current of 9·5 to 10 amperes at an E.M.F. of about 1,800 volts when rotated at a speed of 700 to 750 revolutions per minute. They are connected together in what is known as parallel arc, or for quantity—thus acting as one machine, and giving a current up to nearly 20 amperes. Some little difficulty was at first experienced in arranging the two machines for running together, so that each produced its quantum of the work, and so balanced the work of the other. The machines being originally constructed for arc lighting, also required some modification to convert them to their present purpose, and they are therefore separately excited by means of a small Victoria dynamo, which passes a current of about 10 amperes round the field magnet coils of each, and so excites the magnetic field in which the armature rotates. This Victoria dynamo machine was constructed to specification by the Anglo-American Brush Corporation for the South Eastern Brush Company, and gives an E.M.F. of 150 volts when working through an external resistance of 7·5 ohms. This method of excitation of the magnetism allows of great adjustment of the strength of the magnetic field, so that the power expended in charging less than the maximum number of cells is nearly proportional to the number in charge at any time. The adjustment of the strength of the magnetic field of the large machines to the requirements of the circuit is accomplished by means of an automatic regulator, which limits the supply of current to the field magnet coils in the large machines. It consists of two electro magnets, the armatures of which actuate contact-breaking apparatus in connection with a small electric motor, and which cause the armature of the motor to rotate in either direction, according to the manner in which the connection is made with the source of supply. The rotation of the armature of this motor then actuates a sliding contact, which increases or decreases the resistance in the field magnet circuit of the Victoria machine. The charging current is passed through the coils of the electro-magnets of the regulator, and fluctuations in the current have their effect on the armatures, causing them to be attracted or released according as the current is above or below the normal amount. When, in consequence of an excess in the charging current, one of the armatures is attracted to its electro-magnet, connections are made to the motor in such manner as to cause its armature to rotate, and so actuate the sliding contact, and add resistance in the field magnet circuit of the Victoria machine. This decreases the electromotive force generated, and thus lowers the current in the field magnet coils of the large machines until the strength of the charging current is again brought to its normal. The generation of currents of high electromotive force by means of the Brush dynamo machine presents some difficulties when it is necessary that the maximum E.M.F. should be available at any instant. This arises from the fact that the current generated by these machines is not absolutely continuous, but is a series of waves or pulsations caused by the commutation of the current in which the circuit is broken three times in each revolution of the armature. As a result of this peculiarity it is impossible to run the machine in open circuit when separately excited, and to obviate this difficulty a switch and resistance was constructed. The switch is mounted on a board carrying three current metres. One of these shows the amount of current circulating in the coils of the field magnets of the large machines, another shows the current passing in the resistance coils, and the last shows the current passing in the charging circuit. The first portion of the switch carries the current generated by the large dynamos through the resistance coils, and the amount of resistance in ohms being multiplied by the reading of the current meter gives the value of the electromotive force generated in volts, and on this reaching its maximum the switch is moved to the second position, and the current then passes into the charging circuit. The resistance coils also serve to load the engine up to the amount of work required from it, and thus prevents the pull up and consequent strain which would take place where, from running almost light, a load of 80 horse-power were suddenly put upon it. From the resistance coils and switch and meter board we come to the rocking switch, by means of which we are able to conform to the terms of the license of the Board of Trade under the Electric Lighting Act, 1882. One of the clauses of the license prohibits the introduction of electromotive force of more than 200 volts into the houses of consumers, and although 2,000 or 3,000 volts may be used for the purpose of charging, this apparatus limits the force in the supply mains to the standard pressure required by the lamps in use, which in the case of Colchester is 60 volts. With this apparatus the accidental presence of high E.M.F. in houses is an impossibility, as at the instant of breaking the circuit, either of charge or supply, both circuits will be interrupted for a moment. The rocking switch consists of two rows of 18 iron cups containing mercury, mounted at opposite ends of an insulating base. In the centre of this base a cradle is fixed, in which the rocking bar carrying the contact pieces is suspended by steel centres. Sixteen of the cups at one end of the base are connected alternately with the positive and negative poles of the cascades of batteries ; the two remaining cups at this end being connected respectively to the positive and negative poles of the charging main. Connections are made on the under side of the base from the 16 alternate positive and negative cups to 16 of the cups at the other end of the base, so as to make eight cups on one side positive and the remaining eight negative. A pair of large cups, one at each side, carry the whole of the current to the positive and negative supply mains. The contact pieces carried by the rocking bar are in the form of prongs which dip into the mercury cups. On the charging side they are in detached pairs mounted on an ebonite bar, so as to connect the positive end of one cascade of batteries to the negative end of the next cascade, and so on. On the supply side the contact prongs are mounted on two copper bars connecting all the positive ends of the cascades to one bar and terminal mercury cup, and all the negative ends to the other bar and cup, and from these terminal cups to the supply mains, as before explained. The rocking switches are actuated by automatic means which throw the batteries out of the charging circuit, when the charging process is completed, or so near completion that free hydrogen is rapidly evolved from the positive electrodes, and this operation is carried out by means of the master cell. This master cell is one of the ordinary battery cells to which a simple arrangement is made for collecting the gas given off from one of the positive electrodes of the cell. The gas is collected in an air-tight chamber which partially encloses one of the positive plates, and which extends a short distance below the level of the dilute acid in the cell. In the top of this chamber is an orifice, in which is inserted a tube carrying a loose diaphragm, which is also made perfectly air-tight. On the top of this diaphragm a plunger rests, and this plunger actuates by its rise and fall, according to the distension or contraction of the diaphragm, a small contact-breaker, which makes or breaks a circuit through the electro-magnet which actuates the rocking switches. It is evident, then, that on completion of the charging process and consequent distension of the diaphragm by the free gas evolved, the charging current will be interrupted, and the current energy stored in the batteries will be made available for supply by the fall of the bar carrying the contact pieces or prongs on the discharge side of the rocking switch. The secondary action due to the electrolysis of dilute sulphuric acid with lead electrodes has been studied by Planté since 1859, and it is from his published experiments that all of the many forms of accumulators have sprung. But the form of electrode used in the B.T.K. batteries made by the Consolidated Electric Company has several features rendering it distinct from any other form. The principle of the plate is the use of a band or tape of lead, cut from the sheet by machinery, which renders one side of the tape cellulated or roughened. In the latest form we use a number of very thin tapes, cut as described, and a thicker tape wound or coiled upon them to the required dimensions and pressed into shape. It is then burnt together at the corners to give rigidity when fitted with a cast-lead support or pole-piece. It is then ready for "forming." This "formation" is the name given to the process which the plate undergoes to render it capable of receiving and storing the energy expended in driving the dynamo machine while performing chemical work by the electrolysis of the dilute sulphuric acid. Each cell of the battery contains eleven plates, the supports of which are connected alternately to copper bars on the outside of the cell ; and the copper bars are then provided with a hook attachment for connecting the cells together. They are supported on cast-iron racks, which rest on porcelain insulators on the ground, thus securing very perfect insulation and freedom from danger of making earth. They can be constructed of any capacity up to 360 ampere-hours, the capacity depending on the degree of formation and the thickness of the active material of the plates.

From consideration of the batteries, we come to the question of cables. It is on this ground that one of the claims of the B.T.K. system for economy rests. If it had been decided to light this district of Colchester on

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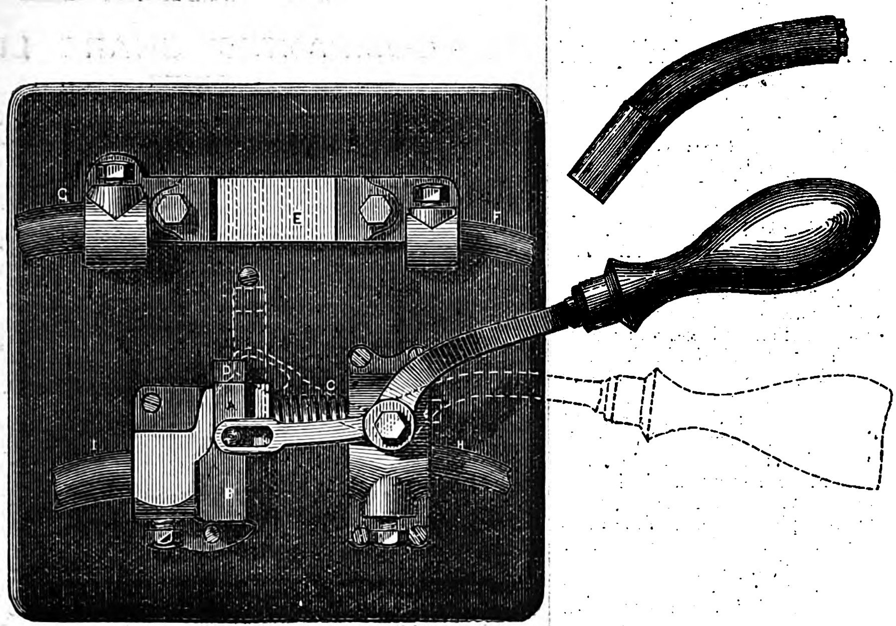
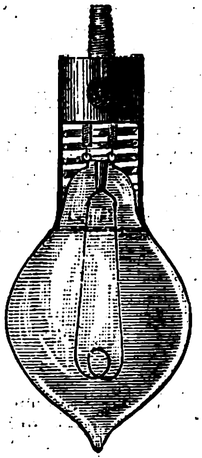
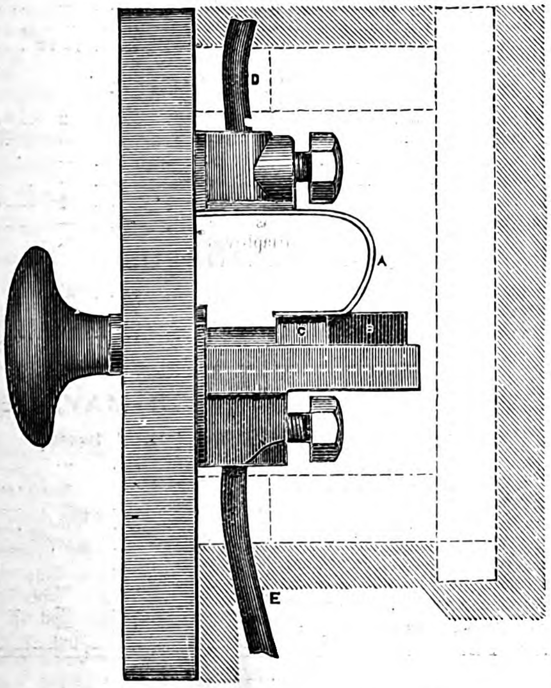
what is known as the parallel system, direct from the dynamo machine, we should have been compelled to spend a very large sum of money in cables, and this I hope to prove by the following simple calculation. We will divide our consideration of the cables necessary for the direct parallel system into two parts :—

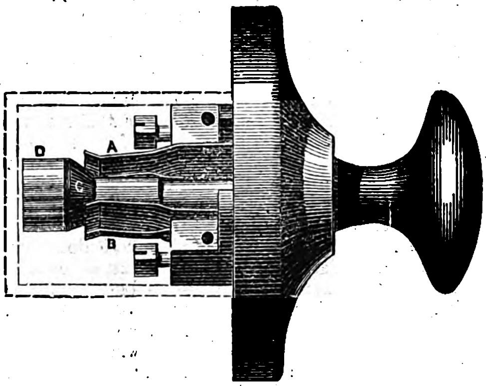
1st. The cable for carrying the whole current from the generating station to the supply mains in Head-street and High-street.

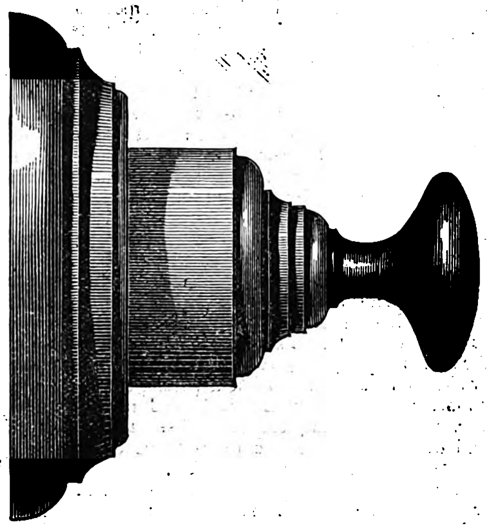
positions. The average length of each branch, lead and return, will be about 333 yards. Now, as the total current required would be about 2,000 amperes, we have to transmit along each branch 666 amperes; a maximum of 2 per cent. fall in the electromotive force is the utmost allowable in this part of the circuit, and on a 60-volt circuit this would amount to 1·2 volts. The resistance of the largest cable we use is about $\frac{1}{7}$ or ·145 ohm per 1,000 yards, and if we used this size for our three











Our diagrams show several forms of switches made by the Consolidated Electric Company, together with their incandescent lamp.

2nd. The supply mains in Head-street and High-street. We will suppose that the supply is to be equally distributed along the whole area, and on both sides of the road.

1st. The cables for carrying the whole current. This would be in, say, three branches from the station in Culver-street; one branch would go to Head-street, and the two others to High-street in the most favourable

branches, we should have a resistance in each of say $\frac{1}{20}$, or nearly ·048 ohm. But to pass 666 amperes through such a conductor as this would be impracticable, on account of heating; besides which it would take an electromotive force equal to 666 × ·05, or 33·3 volts. Our allowance for fall being limited to 1·25 volt, we should have to use a cable the copper conductor of which would equal the sectional area of 27 cables such as the

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largest we use, and the weight of the cable would be about 25 tons. This would cost at least £3,000 or £4,000.

2nd. The mains for supply in High-street and Head-street.—The total length required would be about 5,000 yards, which would be divided, or may be considered as divided, into twelve branches of equal length, each branch being about 416 yards in length, and supplying a maximum current of 166 amperes, with an allowance for variation in E.M.F. of, say, 2½ per cent. The resistance of 416 yards of this 19 No. 12 B.W.G. cable will be about ·06, and to calculate the fall in E.M.F. when using this cable we must multiply 166 by ·06, giving 9·96 volts. But as the current is supposed to be equally distributed this amount will be divided by 2, and we should have a maximum fall of about 5 volts instead of 1·25. From this it will be seen that a cable would have to be used which would equal in sectional area $\frac{5}{1\cdot25}$, or four of these 19 No. 12 B.W.G. cables. Now, as this size costs about £200 per 1,000 yards, it is fair to assume that a cable four times the weight would cost at least three times as much, or about £750 per 1,000 yards, and as the total length is about 5,000 yards the cost will be about £3,800, making in all a grand total for cable of £7,000 or £8,000. I cannot better contrast the cost of cables on the two systems than by the statement that the whole for the supply of 2,000 incandescent lamps on the B.T.K. system have cost about £1,200. The figures speak for themselves, and need no further comment.

The cables as laid for the B.T.K. system are in twenty-one parallels, each distinct from the other, and branching from six battery stations. This division enables us to avoid the use of distributing boxes and also to test any length independently of the rest. They are laid in a brick trench built directly under the pavement, and having wells at distances of fifty feet apart to allow of drainage. The internal dimensions of the trench are 9in. by 7½in., which is ample space for three or four times the amount of cable laid. The road crossings are taken below the surface of the road, and the channel is here supplied with a cast-iron cover made in short lengths and with lap joints. The whole plan is seen at a glance by inspection of the diagrams, and it will be evident that such channelling offers great advantages over the use of iron or other pipes, as the cables can be reached at any place by simply raising a paving stone when junctions for services are requisite, and the pavement can be made good again in less than an hour. One of the regulations to be observed in relation to the supply of electricity under license from the Board of Trade is that:—"In each conductor of each service line shall be inserted a safety fuse of safety connection of a pattern to be approved by the Board of Trade, and which shall be easily accessible." Another rule is:—"That the supply shall be given from two poles situate at not less than three inches from each other, also to be of a pattern to be approved by the Board of Trade." We have here a small box enclosing a combination of safety fuse and service poles, which we think answers to all the reasonable requirements that may be made in this direction, but there can be little doubt that experience will point to some improvements which should be made. The practical limits of utility of a safety fuse or cut-out are that it shall effectively interrupt the passage of the current before any damage can occur to the insulation of the wires by heating consequent on the occurrence of a short circuit. I venture to say that the use of *very* delicate cut-outs of any kind would do more to bring electric lighting into disrepute than anything short of continual breakdowns. For this reason we use lead wire fuses mounted in heavy brass terminals, which, while keeping the fuse cool, will yet allow of the sudden rupture of the circuit when the current reaches a dangerous amount. For private installations we have introduced a mechanical cut-out, which enables the circuit to be re-made by any person. It consists of a lever, on which is mounted two prongs dipping into mercury cups, and held in position by a spiral spring which resists the attraction of an electro-magnet on its armature when only the normal current is passing. When from any cause the current exceeds the amount to which the cut-out is adjusted by, say, 40 per cent., the electro-magnet attracts its armature, and the prongs being released fly out of the mercury cups and thus break the circuit. All that is necessary for the restoration of the circuit is that the box be opened thus [Experiment shown], and the prongs re-inserted by pulling down the lever when light is restored. But all necessity for such systems of cut-out and safety fuse may be avoided by care and judgment in wiring houses. The main points to be considered in laying on a supply of electricity to houses are as follows:—Where long distances are to be traversed, the wire shall not be small enough to have any appreciable effect on the electromotive force when the maximum current is passing. That the shortest route possible be the route taken, and that no wires be taken along or across metal surfaces or near any heated flues or hot-water pipes. Switches should be covered so as to exclude dust. There are a variety of dust-proof switches made, and for rooms requiring up to three lights we recommend the small switches now shown in action. When a person enters a room after dark it is an easy matter to push or pull this little knob, which may be fitted near the door, and on leaving the room the same action will put out the light and thus economise the current. Other forms of switches have their advantages, such as the B.T.K. switch, which it is impossible to turn in the wrong direction, and which cannot be left half on or off; this switch is suited for a number of lamps from 3 to 10 or 12. Then we have the Consolidated lever switch, which acts and wears well and is strong and substantial. In regard to fittings, it is a mistake to cluster the lamps together and to mount them in the heavy fittings which have been designed for gas. We recommend that lamps be suspended from the conducting wires, neatly twisted and terminating in such a mount as the holder in use on this platform. This method gives an airy appearance to the light, and also avoids the danger of short-circuit through drawing wires into metal tubes. The advantage of the form of lamp holder shown is that no part of the conducting circuit is exposed or uninsulated, and so there can never be any danger in consequence of any metal resting on the lamp or holder. Of incandescent lamps there are many varieties and makers, all of which succeed very well in making a globe and filament. But the aim should be to produce a lamp which is at once durable and economical in its consumption of energy. The lamps manufactured by the Consolidated Company are designed to fulfil both these conditions. The 140 candle-power lamps for street lighting, as shown, takes 60 volts and about 4 amperes, giving about 434 candles to the horse-power.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. June 11.		Business Done Week Ending June 11. Highest.	Lowest
Anglo-American	31½,	32½	32	
Do. Preferred	56½,	57½	57½	
Do. Deferred	6¾,	7¼	7	—
Brazilian Submarine	9⅞,	10⅜	10⅜	10
Cuba	9¾,	10¼	10	—
Do. Preference	16½,	17½	—	—
Direct Spanish	4½,	5	—	—
Do. Preference	14¼,	14¾	14½	—
Direct United States Cable	9⅝,	9⅞	9 13-16	9¾
Eastern Telegraph	10⅞,	11⅛	11⅛	11
Do. 6 per Cent. Preference	13¼,	13¾	13⅝	13 5-16
Do. 5 per Cent. Debentures, 1899	103,	107	—	—
Eastern Extension	11¼,	11½	11 9-16	11 7-16
German Union	9½,	9¾	9¾	—
Globe Telegraph and Trust	6⅜,	6⅝	6 9-16	6½
Do. Preference	12¼,	12¾	12½	12¼
Great Northern	13⅞,	14⅛	14½	13¾
Indo-European	30½,	31½	—	—
Mediterranean Extension	1¼,	1¾	—	—
Do. Preference	2,	4	—	—
Reuter's	8,	8½	—	—
Submarine	150,	160	156	—
West India and Panama	¾,	1	⅞	13-16
Do. 1st Preference	6¼,	6¾	6¾	6¼
Western Brazilian	5⅜,	5⅝	5 9-16	—
Western Union 7 per Cent. 1st Mortgage	121,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	106	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅛,	¼	—	—
Oriental	⅛,	⅝	—	—
United Telephone	8,	8½	8 7-16	8

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1⅝,	2	2	1⅞
Do. (fully paid)	3½,	4	—	—
Hammond Light (£3 15s. paid)	½,	¾	—	—
Eastern Electric (£4 paid)	—	—	—	—
Swan	⅜,	⅝	⅝	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	32½,	33½	33¼	33
India Rubber, Gutta Percha, and Telegraph Works	21½,	22½	22¼	22

TRAFFIC RECEIPTS FOR MAY, 1884.

Companies.	May, 1884.	May, 1883.	Increase.	Decrease.
Cuba Submarine	2,950	3,376	—	426
Direct Spanish Telegraph	1,562	1,641	—	79
Direct United States	—	—	—	—
Eastern Extension	35,910	32,156	3,754	—
Eastern Telegraph	51,537	42,960	8,577	—
Great Northern	24,920	—	—	—
Submarine	—	—	—	—
West Coast of America	4,240	—	—	
Western and Brazilian	—	—	—	—

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NOTES.

BELGIUM.—The new Minister of Posts, Railways, and Telegraphs for Belgium is M. Van den Peereboom.

CHICAGO.—The Central Union Telephone Company's new offices in Chicago are to be lighted by the Edison system.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 13th inst. were £2,485.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 13th inst. amounted to £3,139.

THE TELEGRAPH IN CENTRAL ASIA.—A Reuter's telegram dated St. Petersburg, June 16, says telegraphic communication is in course of construction between Merv and Askabad.

NEW ZEALAND.—According to the New Zealand papers a sharp shock of earthquake has been felt at Opotiki, and shocks have also been experienced in the north-eastern parts of the island.

OUTPUT OF BELL TELEPHONES.—The output of telephones for the month ended May 20 was 5,023, against 6,763 in 1883, making a total of 12,758 for the three months of the fiscal year, against 18,844 in like months last year.

AWARD.—The Council of the London Mathematical Society have awarded the first "De Morgan Memorial Medal" to Professor Cayley, F.R.S., for (besides other reasons) his important contributions to the Modern Higher Algebra.

ELECTRIC LIGHTING FOR LIGHTHOUSES.—The Trinity House are inviting tenders for the erection of new dwellings and additional buildings in connection with the installation of the electric light at St. Catharine's Lighthouse, Isle of Wight.

PROTECTION OF SUBMARINE CABLES.—The French Senate on Wednesday, the 14th March, ratified the Convention signed in Paris for the international protection of submarine cables. A translation of this Convention was given in our issue of the 17th May.

SHIP LIGHTING.—An American contemporary says the Bernstein Electric Light Company of Boston, Mass., has fitted its system on a coasting sailing vessel, using the steam power applied to the hoisting apparatus. About fifty lamps are used, including signal lights in the rigging.

SIXPENNY TELEGRAMS IN AUSTRALIA.—It is understood, says the *Colonies and India*, that Mr. W. J. Trickett, Postmaster-General, New South Wales, is about to recommend to the Executive that a sixpenny telegraph rate be extended to all the places enjoying the penny postage.

NEW BOOK.—We have received a copy of the second edition of Mr. A. Bromley Holmes's work on "Practical Electric Lighting," published by Messrs. Spon, of Charing-cross, S.W. Several additions have been made in the new edition, and a chapter has been added on "Secondary Generators."

RAILWAY COLLISION IN AMERICA.—A collision which occurred on the 14th inst. between an excursion train from Camden and an ordinary train from Atlantic City, on the Camden and Atlantic Railway, New Jersey, by which several people lost their lives, is attributed to the negligence of a telegraph operator on that line.

PROPOSED ELECTRICAL CONFERENCE AT PHILADELPHIA.—The Bill authorising the President of the United States to call a national conference of electricians to meet in Philadelphia this autumn has been reported on favourably by the Committee on Commerce, and referred again to the House Committee on Appropriations. The sum asked for is 25,000dols.

ELECTRIC LIGHTING IN AMERICA.—The Detroit, Mich., Board of Aldermen has contracted with the Brush Electric Light Company to light the entire city, from July 1, 1884, to July 1, 1885, with seventy-two light towers, having 300 lamps of 2,000 candle-power each, for 95,000dols. The company erect and maintain the poles, wires, towers, &c.—*Sanitary Engineer.*

ELECTRIC LIGHTING ON THE EMBANKMENT.—The Metropolitan Board of Works have received tenders for lighting the Embankment for three years from the Hammond Electric Lighting Company, Mr. H. E. Edmunds, Messrs. Woodhouse and Rawson, and Mr. Lever. They have been referred to the Works and General Purposes Committee for consideration and report.

THE TELEPHONE IN HOLLAND.—On the first of last month the Netherlands Bell Telephone Company had the following subscribers to its system :—In Amsterdam 1,093, Rotterdam 508, Arnhem 127, The Hague 190, Groningen 72, Utrecht 68, Haarlem 57, Zaandam 14, and Dordrecht 58, or a total of 2,187, of which 1,992 were at that time connected with the various exchanges.

PROVISIONAL ORDER GRANTED.—The Board of Trade has granted a provisional order to the West Middlesex Electric Lighting Company authorising them to supply electricity for the lighting of the district comprised within the area of the Fulham District Board of Works. The order requires the company to set aside £16,000 of their capital to be appropriated for the purposes of the order.

ELECTRIC LIGHTING IN MILLS.—The electric light has been introduced into the woollen mills of Mr. James Clay, at Luddenden Foot, Yorkshire. A Crompton-Bürgin compound self-regulating dynamo supplies current for thirty-six Swan 20 candle-power lamps, which are placed in the carding and spinning rooms, weaving department, &c. The installation has been effected by Mr. Wilson Hartnell, of Leeds.

OVERHEAD WIRES.—Judgment has been given in the case of the Wandsworth Board of Works *v.* The United Telephone Company, in which the company appealed against a recent decision of Mr. Justice Stephen, and the company have gained their case. The Board wished to restrain the company from erecting overhead wires, on the ground that the company committed a trespass on their property in erecting such wires. A report of the case will be found in another column.

FRESNEL.—The Duc de Broglie, mayor of the Commune de Broglie, and President of the Société d' Agriculture, Sciences, Arts et Belles Lettres de Bernay, has, says the *Ville de Paris*, invited the Académie des Sciences to send representatives on the 14th September next to be present at the inauguration of a monument which will be raised in the Commune de Broglie to the memory of Augustin Jean Fresnel, the illustrious physicist, who was born in 1788, and died at Paris in 1827, aged 40.

THE ROYAL SOCIETY.—The following were elected Fellows of the Royal Society at the annual meeting, held last week, at Burlington House, viz.: Professor G. J. Allman, LL.D., Professor J. B. Balfour, Joseph Baxendell, F.R.A.S, Professor A. S. Herschell, M.A., Wilfred H. Hudleston, M.A., Professor Horace Lamb, M.A., Professor John G. M'Kendrick, LL.D., M.D., Arthur Ransome, M.D., Professor Charles S. Roy, M.D.,

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Professor Arthur W. Rücker, M.A., Joseph J. Thomson, B.A., Lieutenant-Colonel Charles Warren, C.M.G., and Professor Morrison Watson, M.D.

THE TELEPHONE IN THE WEST INDIES.—According to a statement made by the manager of the Tropical American Telephone Company, the exchange in Port of Spain has now upwards of 130 subscribers, and it has been arranged to open a trunk line between San Fernando and the capital. Notwithstanding its limited population, about twenty subscribers have already been obtained for the branch exchange it is proposed to open in San Fernando, and from thirty to forty estates in the colony have intimated their readiness to enter the system as soon as the lines can be extended to permit of their doing so.

THE VIENNA STADTTHEATER.—Herr Bukowics, the manager of this theatre, which our readers will remember was burned some time ago, and several *employés* were charged in the police-court at Vienna on Monday last with neglect of duty. We select an item of the evidence as affording food for reflection. It was stated that the fireman in charge of the theatre on the day of the catastrophe, on being informed as he sat in his lodge reading the newspaper that the building was on fire, took a cab and drove to the Central Fire-station, instead of using the telegraph to transmit the news. Hence arose a delay which had the most momentous consequences.

SMALL ARC LAMPS.—Messrs. Siemens Brothers and Co., of Berlin, have recently constructed some small arc lamps which will work in parallel, and do not require more than two amperes of current and an E.M.F. of 40 volts. The upper carbon descends by its own weight, and passes as it is consumed through a hole pierced in a copper disc, the diameter of which is slightly smaller than that of the carbon. The lower carbon is pushed upwards by the action of a spring in a copper tube. A solenoid regulates the length of the arc by its action on a core, to which the upper carbon is attached. The idea is to employ these instead of incandescent lamps, the arc lamps being more economical.

ELECTRIC HOUSE BELLS.—To give our readers some idea of the rapid progress now being made with electric bells for houses in this country we may mention that a contract has been completed for the fitting up of the whole of the Richmond House Estate, comprising no less than 286 houses, with the telegraph bells and indicators of Messrs. Francis and Co., Eagle Telegraph Works, Hatton Garden. This firm, we learn, are also busily engaged in the manufacture of stores for a similar undertaking in Sweden, thus showing that for all ordinary communications, particularly as applied to our homes, this system holds recognised advantages, and it seems that now scarcely any new property is considered complete without these improved and necessary conveniences.

THUNDERSTORM IN FRANCE.—On Sunday last, says a French paper, a heavy thunderstorm occurred between 4 and 6 p.m. at Chatellerault. Telegraphic communication was interrupted for more than two hours, and several buildings were struck. Amongst others a rifle manufactory was struck, although it had several lightning conductors. "This must have been," says our contemporary, "the effect of a return shock." On the previous Friday the lightning struck the semaphore station at Cape Sagro, near Bastia. After having fused the telegraph wires, broken the lightning protector and galvanometer, and spoilt the barometer, the current smashed the window panes to powder. The inmates of the station received some slight wounds, but were otherwise unhurt.

ELECTRIC LIGHTING IN BARROW-IN-FURNESS.—The Criterion Restaurant, Cornwallis-street, Barrow, which has just been opened by Messrs. Case and Co., is lighted throughout by Swan incandescent lamps. The dynamo used is known as the Phœnix, and it is, we believe, identical with what was once called the "Lumley." It is driven by a Robey engine. A switch-board in the dynamo room gives complete control over the lights, and is fitted with one of Andersen's safety cut-outs, which we illustrated and described in our articles on the Vienna Exhibition. The whole of the material has been supplied and the installation carried out by Messrs. Menzies and M'Whirter, electrical engineers, of Glasgow. The volt and ampere meters used in this installation are the invention of Mr. M'Whirter.

A SEWER DAMAGED BY LIGHTNING.—In the course of a thunderstorm which passed over Wigan, in Lancashire, on Saturday week, a day of considerable electrical disturbance throughout the country, as we mentioned in last week's "Notes," a sewer near the town was struck by lightning. A local paper gives the following particulars:—"About half a mile below Dean Lock, below Gathurst, however, the electric fluid appears to have played a very peculiar freak. After striking and completely demolishing a large willow tree it ran along the ground for a distance of about nine feet, then darting downwards it tore up the earth, making a large fissure, and ripped off a piece of the iron outfall sewer piping 6ft. long and 15in. wide, embedding it in the earth out of sight. The pipe, which is 27in. in diameter, is five feet below the surface of the ground."

AN ELECTRIC LARYNGOSCOPE.—Dr. Carl Seller, of Philadelphia, has devised an electric laryngoscope for illuminating the stomach and throat. It consists of an ordinary head mirror, which has attached to its lower rim a bar about four inches long. An incandescent lamp of six candle-power is mounted on the end of the bar, and between it and the reflector is a simple bi-convex lens of short focus, to converge the rays of light on the reflector. On the side of the lamp, away from the reflector, is a shield of silvered mica to protect the patient's face from direct light. The conducting wires run from the lamp to the head-band, to which the reflector is joined by a ball and socket joint, and thence to the battery. Thus the examiner is not dependent on any stationary light; when the mirror is adjusted light is always thrown in the direction of the axes of the eyes.—*Electrical World.*

THE MAGNETIC POLARITY OF IRON.—Captain John Hayden, of Bath, Me., author of "The Requisite Nautical Assistant," writes to the *Scientific American* stating that as long as forty years ago he practically tested, on shipboard, the influence of upright iron bars or masses of iron on the needle. He says: "Iron rods or bars, in a horizontal position, exert but little force on the compass, but the same amount and form of iron placed vertically produce an immense effect on the needle. The iron rod immediately becomes magnetic when placed in a vertical position, its magnetism increasing with the length of time it so remains, although it manifests no magnetism when parallel with the horizon. This effect on iron is most marked when the rod is held or placed in the magnetic meridian, and in the direction of the tipping needle, which is in this country with the bottom end swung to the north about thirty degrees from the perpendicular."

TELEGRAPHIC NEWS TO CLUBS.—In the House of Commons on Monday last, Mr. Fawcett said, in answer to Mr. Houldsworth, that the practice prevailed in certain towns of sending racing news to clubs and then transmitting it by telephone to other clubs and to certain persons. This was regarded as an abuse of the privilege which allowed news to

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be sent at a considerably lower rate by telegraph to clubs than was charged to the ordinary public. Steps had been taken to put an end to the practice. On Tuesday the same hon. member asked a further question, to which Mr. Fawcett replied that news is supplied at press rates to clubs registered at the General Post Office, on condition that such news is used solely for exhibition in the club rooms. The systematic communication of such news to persons other than members of the club, whether the communication be by telephone or otherwise, is held by the Department to be an abuse of the privilege.

THE TELEPHONE IN BRAZIL.—Summarising the annual report of the Companhia de Telegraphos Urbanos, of Rio de Janiero, the *Anglo-Brazilian Times* says :—"Unfortunately, the Companhia Nacional de Electricidade, of which the other company is a licensee, has not been able to induce the telegraph department to permit of telephone communication between Rio and Petropolis. The company had on the 31st March 776 lines working, viz., 627 in Rio, 95 at S. Paulo, 33 at Petropolis, and 21 at Nitherohy, and applications were on file for 601 more. In March the Rio lines alone transmitted 113,424 calls, equal to over 1,350,000 a year. In January the telegraph department exacted that the putting up of all new lines should be effected only by that department, and in consequence the work was transferred to the department, giving rise to delays in attending to new applications. The company has in stock 250 telephones, 10,000 kilograms of galvanised wire, &c., of the value of 32,000dols., and has ordered from England 4,000 metres of insulated air cable having seven wires."

THE GERARD INCANDESCENT LAMP.—M. Gallice writes to *L'Electricien* as follows :—"We have observed something in the Gérard lamp which seems to deserve attention. One of these lamps of 50 candle-power, fed by a one horse-power De Meritens machine, gave a light of about 80 candles. At certain times a violet coloured glow, exactly like that of a Geissler tube, with rarefied air, occupied the lower part of the lamp, at the point where the carbon and platinum wires are soldered together. When a magnetised bar was brought near to the lamp this glow became a kind of flaming ring at the soldering point. Another lamp of the same type, but having less resistance, when run up to nearly 200 candle-power showed the same phenomenon in a still more striking manner. The whole of the glass bulb was occupied by the violet glow. Without knowing the cause of this curious effect, we think it due to the extreme rarefication of the air in these lamps. This fact shows that under certain circumstances the same effects can be obtained with a weak electromotive force not exceeding 50 volts, as with the induced currents of the Ruhmkorff coil. We have not been able to obtain these effects in the lamps of Swan or Nothomb, which we have by us."

METEOROLOGY IN ITALY.—The number of meteorological stations in Italy is 223, of which 92 belong to the Government and 131 to the Meteorological Society. The society of which Father Denza is president furnishes, moreover, a portion of the apparatus to 60 out of the 92 Government stations. These 92 stations send their daily reports by telegraph to the central office in Rome, which should receive them at 7 a.m., local time. The Rome office summarises their contents, and despatches them to the central offices of all nations connected with the international service, and receives in exchange the same information from Russia, Sweden, Norway, Germany, Austria, Belgium, Holland, Switzerland, France, Turkey, England, and Spain. In all fourteen messages are sent and fourteen received. As each country does the same, the number of international messages circulating ea ch morning is 196. If a central international office was established at Berne, for instance, where there is already a central postal and telegraph office, it would be sufficient if 14 messages were despatched and 14 received, or 28 messages would do for the whole service. The managers of the meteorological stations are either astronomers, university professors, sailors, engineers, telegraph *employés*, or amateurs with a taste for science.—M. de Fonvielle, in the *Ville de Paris*.

ELECTRIC LIGHTING AT HULL.—The opponents of electric lighting on the Hull Town Council very nearly succeeded in terminating Messrs. Siemens' contract for supplying certain arc lamps in that town a few days since. One of the members of the council at their last meeting moved as an amendment to the resolution confirming the minutes of the lighting committee, which minutes recommended the continuance of the electric lamps, "That the contract with Messrs. Siemens, terminating on the 28th of July, be not renewed." He stated that the cost of 26 electric lamps from March, 1883, to March, 1884, was £1,824 8s. 11d., which, together with 39 gas lamps, costing £250 3s., made a total of £2,074 11s. 11d. as the cost of the electric light. They formerly paid the gas company for lighting the whole of the old town £1,074 11s. 7d., and he argued that, if they merely wanted to improve the old town, they could provide improved gas lamps for another £1,095. The amendment was seconded by Mr. Shaw.—Mr. Elam (chairman of the Lighting Committee) pointed out that the electric light had enabled the town to get a reduction in the price of gas both for street lighting and domestic purposes. He asked the council to support the committee in continuing their endeavours to protect the town and its interests in that respect.—The amendment on being put was lost.—On a division, the result of the voting was :—For the amendment, 20; against, 21.—Mr. Pool gave notice that, at the next meeting of the council, he would move the amendment as a resolution.

THE BENTON IRON CELL.—In his report on "Submarine Mines," Col. Abbot, of the United States Corps of Engineers, writes as follows of the Benton iron cell :—"A battery capable of occasionally supplying a moderately strong current, and which can be left standing without the destructive local action inherent in every form of the nitric acid cell, is sometimes useful, and Colonel Benton has devised the following pattern to meet this end. The jar is of cast iron, 6½in. in diameter, and 6½in. deep. The positive plate, also of cast iron and cylindrical in form, exposes 140 square inches to the surrounding fluid, which consists of a saturated solution of sodium chloride (1lb. to 4⅝lb. of water). The negative plate consists of a carbon slab, ·8 by 2 by 9in. long, immersed 7in. in a porous cup of white earthenware filled with the following mixture :—6oz. of peroxide of manganese, 6oz. of broken carbon, 8oz. of water, 5¼oz. of sulphuric acid, and 1½oz. of a saturated solution of potassium bichromate in nitric acid. The surface of the carbon plate exposed to the fluid is 40 square inches. The internal resistance of this cell, when fresh, is ·18 ohm; but it rapidly increases after the circuit is closed. The electromotive force is about 1·5 volt. The peculiarity of the cell appears to be the rapid increase of internal resistance. A solid deposit begins to form at the bottom of the jar and in the pores of the porous cup shortly after the closing of the circuit, and it appears to increase while the work continues. This is the worst feature of the combination, since it involves frequently washing the porous cup in dilute muriatic acid to prevent the steady increase of

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internal resistance. When only occasional work is required this difficulty is less troublesome, as there is an evident tendency to re-dissolve during intervals of rest."

A Photometrical Standard.—The Gas Institute some time since appointed a committee to report upon a standard of light for photometrical purposes. Their report was presented at the annual meeting of the Institute held last week. From this it appears that the committee resolved that, as any standard having a wick as one of its component parts cannot be relied upon to give unvarying results, the sperm candle only (being the present standard in this country) should be tested as representing this class; and that the other suggested standards to be tested should be—the Methven screen, the Harcourt air-gas, the Harcourt air-gas lamp, the Giroud *vérificateur*, and the Giroud relative standard. The deductions to be drawn from the report are—That candles of different makers, all complying with the parliamentary definition, give very discordant results. That candles from the same maker vary in the results they give, though to a less extent; and that therefore the candle is not reliable as a standard. That the Harcourt standards are not convenient, or suited for use in general photometry, as they demand too much attention from the operator. That the Giroud standards "are not exact enough to be adopted as absolute standards." That the amount of light passing through the slot of a Methven screen from an Argand burner in which gas varying from 14 to 22 candles illuminating power is consumed, and from gas of any quality when carburetted in a defined manner, is practically invariable, and may therefore be relied upon at all times, and under all circumstances be of equal value and give out the same amount of light. The committee add that if it be thought objectionable to use coal gas as a means of producing the standard light, Harcourt's air-gas, or even air carburetted with highly-rectified petroleum, may be used, as they have ascertained that they both give reliable results with properly proportioned Methven slots. The report is to be published as an appendix to the *Transactions* of the Institute for this year.

The Life of a Ten-candle Lamp.—Herr Zacharias has made some experiments on the life of incandescent lamps, which he has published in the *Zeitschrift für Electrotechnik*. He found that a lamp of 10 candle-power (normal) would last for the undermentioned number of hours when giving the different candle-powers mentioned below:—

Candles.	Hours.	Candles.	Hours.
10	5,550	19	534
11	3,963	20	443
12	2,857	21	371
13	2,134	22	312
14	1,628	23	266
15	1,292	24	228
16	1,000	25	196
17	802	30	163
18	651		

The life of an eight candle-power lamp (normal) he found to be as follows:—

Candles.	Hours.	Candles.	Hours.
8	2,260	15	233
9	1,470	16	179
10	1,000	17	145
11	714	18	118
12	512	19	96
13	385	20	80
14	290		

The duration of the lamp is therefore a relative quantity, and depends upon the current which is supplied to it. Now it is manufactories which make great use of the electric light, and in the greater portion of them to raise or lower the elastic power of the steam by one to half an atmosphere is to proportionally vary the power of the motor, and consequently the current furnished by the dynamo. Why not employ a voltmeter for the engine driver to consult? The utility of this apparatus is shown by the following example:—Herr Zacharias had occasion to install electric lamps in a paper mill and another works under exactly similar conditions, viz., same machines and the same mounting and fittings. The only difference was in the motor and the engineer. The works were supplied with power by an old single-cylinder engine, which worked most irregularly, whilst the other had a three-cylinder engine; but the engineer of the former was constantly looking after the working of his apparatus. He had a voltmeter and a variable resistance at his disposal, which enabled him to take care that the E.M.F. remained uniform at 98 volts. Now, half the lamps at the works (each requiring 50 volts) lasted for 2,800 hours, whilst in the paper mill, the installation in which was completed several weeks later than the other, a large number of lamps had to be renewed within a short time.

Telephonic Communication.—In the House of Commons on Thursday, the 12th instant, Mr. Fawcett was asked several questions on this subject. We take the following report of what occurred from *The Times*. In the first instance, Mr. Whitley asked the Postmaster-General whether he was aware that the Post Office had refused to allow the same advantages of telephonic inter-communication to Liverpool and Birkenhead, which are divided by the River Mersey, as are allowed to Manchester and Salford, which are divided by the River Irwell; and whether he was prepared to reconsider the application of the Lancashire and Cheshire Telephone Company to establish communication between the two licensed areas, so as to give the people of Liverpool and Birkenhead the facilities which are enjoyed by Manchester and Salford.—To this Mr. Fawcett was understood to reply that Salford and Manchester were served as one town for postal and telephonic purposes. The same connection did not exist between Liverpool and Birkenhead, which had each a separate telephonic and postal system. He regretted, therefore, that he could not accede to the request of the hon. member, but he thought that telephonic communication between Liverpool and Birkenhead should be by trunk wire, the same as between Liverpool and other towns. Mr. Whitley asked whether that would not be very expensive. Mr. Fawcett said it would, no doubt, be more expensive.—Mr. Briggs then asked whether Mr. Fawcett was aware that the Lancashire and Cheshire Telephone Company were desirous to open call offices in the various towns in their district, whereby for a small payment the public might converse with subscribers to the Telephone Exchange; whether the Postmaster-General insisted upon the company charging 1s. each time such facility was afforded, and whether he could see his way to relax these terms.—Mr. Fawcett answered that the subject of this question had been for some time under careful consideration, and he regretted that he was unable to sanction any smaller charge than 1s., the minimum amount now charged for an inland telegraph message.—Mr. Jacob Bright asked the Postmaster-General whether by letter dated April 18, 1883, addressed to the Lancashire and Cheshire Telephone Company, the Post Office consented to erect and maintain wires for telephonic communication between town and town for a guaranteed payment of £10 per mile per annum; and if, in such letter, the company were to be allowed to obtain as many subscribers

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as they could for each wire, and to charge whatever annual rate they chose, so long as no favour or preference was shown —that is to say, so long as precisely the same rate was charged to every subscriber for the same use of a wire; whether, when the company accepted the conditions and announced their intention of bearing the entire cost themselves and giving the advantages to the subscribers, free of charge, the Department refused its assent to such an arrangement, and ultimately insisted upon the company charging a minimum annual rental of 10s. per mile of distance between town and town, or, if the subscription was monthly, a minimum charge of 18s. per mile per annum; whether he was aware that, in the opinion of the company, these rates were practically prohibitive, and whether he would consider the advisability of so modifying them as to give to the people of Lancashire and Cheshire the advantages which the company are ready and willing to offer them, of being able to converse between town and town of the district on reasonable terms.—Mr. Fawcett in reply said that he could not, without unduly encroaching on the time of the House, explain all the details of the correspondence which had taken place, but would be glad to show it to any hon. member who would call at the Post Office. He did not think he would be justified in making any modification in the terms to which the Department had agreed with regard to trunk wires.

Earth Currents.—Mr. H. Wild has communicated the results of observations on earth currents made in the Observatory of Paulowsk, Russia, to the *Bulletin* of the St. Petersburg Academy of Sciences, and we extract the following from a translation of his article which appears in the supplementary number of the *Phil. Mag.* for this month:—"Thanks to the kindness of the Directorate of Russian Telegraphy, the Meteorological and Magnetic Observatory of Paulowsk has already, since the month of August, 1882, been in possession of two submarine lines, each a kilometre in length, one being perpendicular and the other parallel to the magnetic meridian. Each of these lines is connected with an aperiodic galvanometer set up in the underground pavilion for observing magnetic variations; so that the readings of the scale may be made at the same time as those of the variation instruments." . . . .

"The calculation of the observations made regularly during the period from September, 1882, to September, 1883, has been so far advanced as to enable me to communicate to the Academy some interesting results which I have deduced from them:—(1.) The earth current at Paulowsk in our lines of *one* kilometre in length is usually manifested not as a current which flows for some time in a certain direction, and the force of which varies slowly, but as more or less strong alternating currents, which change rather rapidly their direction in space. (2.) The component of the earth current which appears in the E.-W. line is generally stronger than that observed in the N.-S. line; the direction approaches therefore the parallels rather than the meridians. (3.) The observations of the term-days, taken separately each day, do not show a daily course of the earth current either in respect of magnitude or number of oscillations. But taking the mean of 24 term-days, a sufficiently distinct, though small, daily course is seen. The current in the S.-N. line indicates a maximum between 4 and 5 o'clock in the morning, and a minimum at 8 o'clock in the evening; and the current in the W.-E. line a maximum at 8 a.m., and a minimum at 1 p.m. The amplitude of this oscillation is very small, only corresponding for the two components to about 0·0008 volt. This variation does not coincide with the normal variation of the magnetic elements; and it follows that the daily variation of the earth currents cannot be regarded as the origin of the daily variation of the magnetic elements. (4.) As soon as the earth current shows itself in the two lines with greater force, the magnetic instruments begin to diverge from their regular course; and these disturbances increase in general with the strength of the earth currents without there being any strict proportionality between the two classes of phenomena. On the 15th of November, 1882, for instance, the earth currents showed themselves in greater strength in the two lines than on the 1st of March, 1883; and nevertheless the course of the magnetic instrument on the first of these days was far more irregular than on this latter day. (5.) If, as Sir G. Airey has already done for similar observations at the Greenwich Observatory, we compare the current in the S.-N. line with the changes in the declination, and the current in the W.-E. line with the changes in horizontal intensity, we often find, especially for somewhat slow changes, perfect equality between these two kinds of disturbances; but the variation of the current always precedes that of the earth's magnetism by at least five minutes, so that the current appears as the primary cause of this latter. Thus the motion of the magnetic apparatus is always that which would be required by the fundamental law of electro-magnetism, if the earth current had a direct influence on the magnets. If, for instance, a positive current from north to south shows itself in the N.-S. line, the easterly declination of the needle increases at the same time; and if in the E.-W. line a positive current goes from east to west, the horizontal intensity of terrestrial magnetism becomes greater—that is to say, the north pole of the bifilar moves towards the north. The retardation which the indications of the magnetic instruments experience relatively to those of the galvanometer could be explained by the hypothesis that the earth current, which directly influences the magnets of the galvanometers, only acts on the variation instruments by the magnetisation of the more or less thick layers of earth, and this requires a certain time. (6.) This retardation in the effects of the earth current explains, partially at any rate, the want of strict proportionality between the variations of the current and the magnetic elements. It is observed that the proportionality fails particularly when the changes in the current are very frequent and alternating; and it is more complete on those days on which the disturbances are not sudden. Now it will be readily understood that in the former case the transitory currents in opposite directions which rapidly succeed each other will be partially destroyed by the magnetisation of the earth, so that the variations of the magnetic instruments will be relatively smaller. The observations of the 15th November, 1882, and of 1st March, 1883, as well as the curves registered by the magnetograph, support this explanation. The curves registered on the 1st of March show by the clearness of the lines a relatively tranquil course of the magnets, although the slow disturbances have been somewhat large; and, in consequence, the curves drawn from the readings of the galvanometers are not very marked, and those of the S.-N. current are very similar to the curves of the unifilar, while those of the E.-W. current are in close agreement with the registrations of the bifilar. On the other hand, the two kinds of curves of November 15 show little agreement with each other; and although the variations of the two currents are very great and very rapid, the registers of the magnetograph, as well as the direct observations of the magnetic instruments, do not show great perturbations; but if we examine more closely the curves registered, we easily observe the traces of a permanent oscillation of magnets within small limits. *We may then conclude that earth currents are always the primary cause of magnetic storms, but not of the periodical variations of the magnetic elements.*"

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ELECTRO-CHEMISTRY.—Inorganic.

BY DR. G. GORE, F.R.S.

(CONTINUED FROM PAGE 103.)

Magnesium is a very highly electro-positive metal; it deposits in the metallic state nearly all the base and noble metals from solutions of their salts by simple contact. According to Roussin, it deposits bismuth, platinum, gold, silver, mercury, copper, lead, thallium, tin, and cadmium (*Chem. News*, Vol. XIV., p. 27). In addition to these, according to Phipson, it deposits nickel, cobalt, and zinc, and even iron and manganese, from solutions of ferrous and manganous salts; but it does not deposit aluminium from its solutions (Watts's "Dictionary of Chemistry," Vol. V., p. 795).

A sub-oxide of magnesium appears to be formed when sodic or ammonic chloride is electrolysed with electrodes of magnesium wire, the anode being covered with the black oxide (W. Beetz, Watts's "Dictionary of Chemistry," Vol. VI., p. 796). I have obtained this compound in a great variety of liquids by immersing magnesium in contact with platinum or palladium in them; solutions of chloride and bromide of potassium or sodium were some of the most suitable liquids (*Proceedings* Birmingham Philosophical Society, Vol. IV., Part I.).

The metal is deposited by means of a separate current. According to Bertrand, an adherent deposit of the metal may be obtained by electrolysing during a few minutes a concentrated aqueous solution of the double chloride of magnesium and ammonium by means of a very powerful current and a cathode of copper (*Chem. News*, Vol. XXXIV., p. 227; *Jour. Chem. Soc.*, 1877, Part I., p. 161). Bunsen obtained it by electrolysing fused chloride of magnesium at a red heat in a deep and covered porcelain crucible which was divided by a vertical partition of porous porcelain extending from the top to half way down the vessel. The current employed was from ten zinc and carbon elements. The electrodes were of carbon and were introduced through openings in the cover, and the cathode was notched, so that the light melted metal collected in the notches, instead of rising to the surface and then burning. Matthiessen states that the metal may be much more easily obtained by this method if the salt employed consists of a mixture of four molecules of magnesic chloride, three of chloride of potassium, and a little chloride of ammonium. In this case, the liquid salt being lighter than the magnesium, the latter falls to the bottom (Watts's "Dictionary of Chemistry," Vol. II., p. 438; Vol. III., p. 751).

For the use of electrolysis in the metallurgy of magnesium see F. Fischer, *Jour. Chem. Soc.*, Vol. XLIV., 1883, p. 399.

Separation of Thorium.—Atomic weight = 233·9. Sodium sets free metallic thorium from fused double chloride of thorium and potassium in an iron crucible (L. F. Nilson, *Jour. Chem. Soc.*, Vol. XLIV., 1883, p. 152).

Separation of Norwegium.—Atomic weight = 145·9 (?). According to Dr. Tellef, the sulphate solution of this metal is turned brown on the addition of zinc, and the metal is deposited in the pulverulent state (*Chem. News*, Vol. XL., p. 25).

Separation of Cerium. Ce. Atomic weight = 94·2. **Lanthanum.** La. Atomic weight = 92, and **Didymium.** Dy. Atomic weight = 96.—Crude double chloride of cerium and potassium in a fused state at a red heat is decomposed by metallic sodium, and metallic globules of impure cerium, together with shining scales of an oxychloride of cerium, are obtained (Wöhler, Watts's "Dictionary of Chemistry," Vol. VI., p. 419).

When a mixture of oxide of cerium and potassic fluoride is melted in a porcelain crucible, and subjected to electrolysis, potassium and silicide of cerium in the form of a brown mass are deposited upon the cathode (Ulik, Watts's "Dictionary of Chemistry," Vol. V., p. 266; and Vol. VI., p. 420).

According to Bunsen either of these metals may be separated by electrolysis with a separate current in the following manner:—Its chloride is mixed with sal-ammoniac (both as dry as possible), and the mixture heated to redness in a platinum crucible to expel all the sal-ammoniac. A porous clay vessel of the best quality is filled with the residue, then placed in a Hessian crucible, surrounded by a cylinder of sheet iron (with a long projecting strip for connection) to serve as the anode, and the space between the two vessels filled with a previously melted mixture of an equal number of equivalents of the chlorides of potassium and sodium. A thick iron wire, enclosed in a clay pipe, has a coil of very fine iron wire at its extremity to serve as the cathode, and is immersed in the fused salt in the inner vessel. The fusion is effected by preference in a fire of glowing charcoal, to prevent as far as possible the presence of aqueous vapour, and a strong current is employed (*Electrical News*, Vol. I., p. 184; *see* also Hillebrand and Norton, Watts's "Dictionary of Chemistry," Vol. VIII., pp. 420-421).

T. Schuchardt states that he has succeeded in obtaining by electrolysis metallic cerium in globules weighing from four to five grammes; and that he has also by the same process, with the aid of a current from six Bunsen's cells, obtained metallic didymium in globules the size of a pea (*Chem. News*, Vol. XL., p. 35). Hillebrand and Norton also state that they have obtained each of these metals by means of electrolysis (*Jour. Chem. Soc.*, 1876, Part II., p. 276).

According to C. Erk, the electrolysis of a neutral solution of cerous nitrate by means of a current from three Bunsen's cells yielded at the cathode a brownish-yellow mass and a quantity of ammonia sufficient to precipitate the whole of the cerium. A concentrated one of cerous chloride gave free chlorine at the anode and a deposit of ceroso-ceric hydrate at the cathode. The same salt in a state of fusion, with an anode of gas-carbon, gave small quantities of metallic cerium, and reddish white laminæ of cerium oxychloride at the cathode; and at the anode hydrochloric acid was evolved, and a large quantity of ceroso-ceric oxide formed. Strong solutions of cerous sulphate became yellow at the anode from formation of ceroso-ceric sulphate, and at the cathode yielded a little metallic cerium and a waxy deposit of ceroso-ceric sulphate, which subsequently became crystalline. An aqueous solution of cerous acetate yielded a basic acetate (Watts's "Dictionary of Chemistry," Vol. VII., p. 274).

Separation of Gallium.—Ga. Atomic weight = 69·86. Gallium is allied to aluminium and also to mercury. Cadmium separates gallium in the metallic state from a boiling solution of its chloride by prolonged immersion (M. Lecoq de Boisbaudran, *Jour. Chem. Soc.*, Vol. XLII., 1882, p. 897). So long as the liquids are sensibly acid, and the evolution of hydrogen goes on actively, zinc does not precipitate either the chloride or sulphate of gallium; but when the liquids become basic, and hydrogen is evolved but slowly, either the oxide or a subsalt of gallium separates in white flakes mixed with subsalts of zinc (M. Lecoq de Boisbaudran, *Chem. News*, Vol. XXXV., p. 158).

On passing a current from five bichromate cells through an ammoniacal solution of sulphate of gallium, with platinum electrodes, metallic gallium is deposited on the cathode, and a white film is formed upon the anode. In four and a half hours the metallic deposit weighed ·0016 gramme. With ten cells, in five hours it weighed ·0034 gramme. The metal was adhesive, not easily burnished by friction, but better by pressure (Lecoq de Boisbaudran, *Jour. Chem. Soc.*, 1876, Part I., p. 521; *Chem. News*, Vol. XXXV., p. 150).

According to Schicht, by electrolysis, gallium, like zinc, is deposited completely and in a pure state upon the cathode (*Chem. News*, Vol. XLI., p. 280.) By the electrolysis of a solution of oxide of gallium in one of caustic potash, by means of a current from five or six Bunsen's cells, and platinum electrodes, metallic gallium is deposited as liquid globules. (M. Lecoq de Boisbaudran, *Chem. News*, Vol. XXXV., pp. 150 and 168).

(TO BE CONTINUED.)

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CORRESPONDENCE.

THE POTENTIAL AT POINTED PORTIONS OF A CHARGED CONDUCTOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the very interesting paper by Professor Tait on "Thunderstorms," published in your last issue, the author states:—"Since we are dealing mainly with *motion* of electricity, it is necessary to consider to what that motion is due. You all know that winds, *i.e.*, motions of the air, are due to differences of pressure. . . . Similarly the cause of the motion of heat in a body is difference of temperature. . . . Now, electricity presents a precisely analogous case. It moves in consequence of difference of *potential.* Potential, in fact, plays, with regard to electricity, a part precisely analogous to the *rôle* of pressure, or of temperature, in the case of motions of fluids and of conducted heat."

Further on the Professor says:—"On a very elongated body, terminating in a point, for instance, the electric density—that is the quantity per square inch of surface—may be exceedingly great at the point, while small everywhere else. Now, in proportion to the square of the electric density is the *outward pressure* of the electricity tending to escape by forcing a passage through the surrounding air."

The above would seem clearly to imply that pressure, or potential, is greater at pointed portions of a charged conductor than elsewhere—at a flattened portion, for instance. Can this be what the Professor intended to convey? The view that such is the case was at one time held by the late M. Du Moncel (vide *The Electrician* of April 12th, 1879). It is also, I believe, still held by many who accept the "law of the inverse squares of the distances" as a fundamental law of electrical attraction, and who have not realised that there is an electrostatic *circuit,* which is absolutely analogous to the conductive circuit.

As a matter of demonstrable fact, the pressure or the potential at the pointed portions of a charged conductor is always *less* than at its more flattened portions.—Yours, &c.,

DESMOND G. FITZGERALD.

PROFESSOR EWING AND THE COST OF ELECTRIC LIGHTING IN DUNDEE MILLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Permit me to submit one or two remarks through the columns of your paper upon that portion of Professor Ewing's lecture, as reported in last week's issue, which deals with the question of cost of electric lighting in Dundee mills. There is no doubt but that the jute and linen mills in Dundee form a very large field in which electric lighting could be easily introduced, and give the best opportunities electric light companies could have. Some of these mills alone use over 6,000 lights, and the majority of them have plenty of engine power available to drive the machines.

Within the last two years it has been part of my duty to prepare estimates for mill lighting (amounting to a total of about 20,000 incandescent lamps) for different firms in this district, but not a single one of these resulted in an order, owing to the enormous cost of the plant, although I quoted the prices as low as could be done consistent with efficiency. In these estimates nothing was put in for engines or any other machinery—merely that of the dynamos, lamps, and wires; and in every case it was found that a very moderate percentage for interest and depreciation of the plant alone amounted to more than the annual gas bill, thus allowing nothing for the expense of fitting up the installation, or the renewal of lamps, coal, oil, attendance, &c.

I certainly should be delighted to find that Professor Ewing is right, but would be glad to know the details of his estimate in which he makes it appear that in the case of an installation of 500 20 candle-power lamps with the power supplied from existing engines the cost is almost the same as gas, including everything, such as the interest and depreciation, renewal of lamps, coal, oil, and attendance. The following are the details of one of my estimates for 500 incandescent lamps to light a public work in Dundee using 500 gas jets:—

	£	s.	d.
3 compound wound dynamos	£700	0	0
400 20 candle-power lamps, with holders, at 5s. 6d. each	120	0	0
120 10 candle-power lamps, with holders, at 5s. 6d. each	33	0	0
540 yards of 19 No. 12 cable	96	15	0
860 yards of 7 No. 14 cable	53	15	0
288 yards of 7-16 cable	10	4	0
162 yards of 7-14 cable	5	8	0
3,600 yards of small wire for single lamps	22	10	0
16 switches for circuits	8	0	0
1 main switch	5	0	0
6 switches for 14 to 26 lamps	1	1	0
16 fusible plugs for 20 candle-power lamps	4	0	0
6 fusible plugs for 10 candle-power lamps	0	18	0
	£1,060	11	0

Now, the cost of lighting with gas the same work for which this estimate was prepared is about £100 per annum, some years a pound or two more or less. The gas accounts were submitted to me for examination, and I know, therefore, that I was not deceived. You will thus see that to keep the electric light as cheap as gas you had only £100 per annum to meet interest, depreciation, renewal of lamps, coal, oil, and attendance, which it must be apparent to all is utterly inadequate.

I heartily endorse the professor's remarks as to the question of comfort and health of the workers, but I doubt if this is sufficient in itself to induce the Dundee manufacturers to go in for electric lighting if it is to cost more than gas.

In conclusion I may say that if the professor is right in his estimate, and I could find a company to supply the apparatus sufficiently cheap to keep the electric light about the same cost of gas, I have no fear I could do a very extensive business here.—Yours, &c.,

W. C. MARTIN.

Commercial-street, Dundee.

THE CRUTO LAMP—A DISCREPANCY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the table quoted (*The Electrician,* May 31st, p. 62), by M. A. Bandsept, the number of candles per horse-power in the case of the Cruto lamp is given as 103·58; whilst the corresponding number in the case of the Edison lamp is 144·88. But Mr. Bandsept says:—"If with these data before us we compare the economy of the Cruto lamp . . . with that of Edison, for instance, we find that the latter gives about twice the light for the same expenditure of energy." There is obviously here an error; perhaps Mr. Bandsept may be able to rectify it.—Yours, &c.,

HOLLOW CARBON.

TELPHERAGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In case any of your readers may be sufficiently interested in telpherage to give up a day to its inspection, will you allow me to state that the telpher line at Weston may be seen in action any day next week. The train will be kept running for the greater part of each day, so that no notice need be given by intending visitors; but in case of accident it might be well before starting to inquire at 12, Fitzroy-street, whether the train was running on that day. The line is in a field close to the village of Weston, and is reached by a drive of five or six miles from Stevenage or Hitchin. The drive from Stevenage is the shorter of the two. Visitors should inquire at the town farm for Mr. Brewtnall, who will give all necessary explanations.—Yours, &c.,

FLEEMING JENKIN.

Offices of the Telpherage Company,
53, Old Broad-street, E.C.

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THUNDERSTORMS.

BY PROFESSOR TAIT, F.R.S.

(CONCLUDED FROM PAGE 117.)

"On September 3rd there was a great deal of streamers, which rose nearly from the same point that the thunder afterwards came from, and gradually worked north till they descended below the horizon. The air had a thunder-like appearance for several days before this storm; and for some nights after it the streamery vapour appeared equally diffused, muddy, inert, and languid, and not vibrating any variety of colours, as if the more volatile parts had been consumed. It is highly probable that lightning and the *aurora borealis* are of the same materials. In hot countries streamers are not seen, or but rarely, because they are kindled into thunder and flashes of lightning. In cold countries streamers abound, and it seldom thunders. The streamers have served to predict thunder to follow next day, in summer, and they have been also seen to break out into flashes of lightning. Thunder disturbs the motion of the magnetic needle, and it has been lately found in Sweden that streamers do the same. Thus thunder, electricity, magnetism, and the *aurora borealis* appear all wonderfully related; and many things remain undiscovered in this vast field, which is but just newly opened.

"As it is probable that the height which some philosophers have assigned for the streamers in the atmosphere is by several hundreds of miles too much, it were to be wished that people in various latitudes would carefully observe their altitude at different times of the night, that by comparing simultaneous observations this matter may be determined with more certainty."

At first reading one is inclined to regard this as a joke, but there is nothing whatever to justify the notion. That Dr. M'Fait was not killed on this occasion was certainly not due to any want of precautions on his part, well calculated to make such an event all but certain. He wanted only a knob on the blunt end of his short rod. Richmann, of St. Petersburg, had just before been killed while apparently in far less danger than Dr. M'Fait, and other incautious experimenters have since similarly suffered.

The destructive effects of lightning are familiar to all of you, so that I need not spend time in illustrating them on a puny scale by the help of Leyden jars.

All the more ordinary effects can thus easily be produced on a small scale. How small you may easily conceive when I tell you that a three-foot spark is considered a long one, even from our most powerful machines, while it is quite certain that lightning flashes often exceed a mile in length, and sometimes extend to four and five miles. One recorded observation, by a trustworthy observer, seems to imply a discharge over a total length of nearly ten miles.

When a tree is struck by a violent discharge it is usually split up laterally into mere fibres. A more moderate discharge may rupture the channels through which the sap flows, and thus the tree may be killed without suffering any apparent external damage. These results are usually assigned to the sudden vaporisation of moisture, and the idea is probably accurate, for it is easy to burst a very strong glass tube if we fill it with water and discharge a jar by means of two wires whose extremities are placed in the water at a short distance from one another. The tube bursts even if one end be left open, thus showing that the extreme suddenness of the explosion makes it act in all directions, and not solely in that of least resistance. When we think of the danger of leaving even a few drops of water in a mould into which melted iron is to be poured, we shall find no difficulty in thus accounting for the violent disruptive effects produced by lightning.

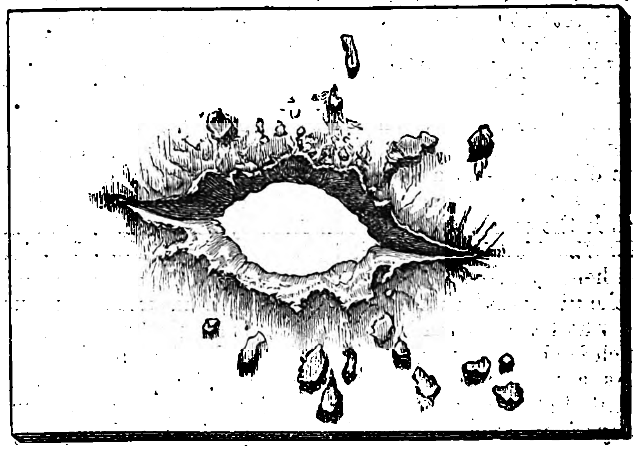
Heated air is found to conduct better than cold air, probably on account of the diminution of density only. Hence we can easily see how it is that animals are often killed in great numbers by a single discharge, as they crowd together in a storm, and a column of warm air rises from the group.

Inside a thundercloud the danger seems to be much less than outside. There are several instances on record of travellers having passed *through* clouds from which, both before and after their passage, fierce flashes were seen to escape. Many remarkable instances are to be found in Alpine travel, and specially in the reports of the officers engaged in the survey of the Pyrenees. Several times it is recorded that such violent thunderstorms were seen to form round the mountain on which they were encamped that the neighbouring inhabitants were surprised to see them return alive.

Before the use of lightning-rods on ships became general great damage was often done to them by lightning. The number of British ships of war thus wholly destroyed or much injured during the long wars towards the end of the last and the beginning of the present century is quite comparable with that of those lost or injured by gales, or even in battle. In some of these cases, however, the damage was only indirectly due to lightning, as the powder magazines were blown up. In the powder magazine of Brescia, in 1769, lightning set fire to over two million pounds of gunpowder, producing one of the most disastrous explosions on record.

A powerful discharge of lightning can fuse not only bell-wires, but even stout rods of iron. It often permanently magnetises steel, and in this way has been the cause of the loss of many a good ship; for the magnetism of the compass-needles has been sometimes destroyed, sometimes reversed, sometimes so altered that the compass pointed east and west. And by the magnetisation of their steel parts the chronometers have had their rates seriously altered. Thus two of the sailor's most important aids to navigation have been simultaneously rendered useless, or, what is worse, misleading; and this, too, at a time when, because of clouds, astronomical observations were generally impossible. All these dangers are now, however, easily and all but completely avoidable.

A very singular effect of lightning sometimes observed is the piercing of a hole in a conducting-plate of metal, such as the lead covering of a roof. In such a case it is invariably found that a good conductor well connected with the ground approaches near to the metal sheet at the part perforated. We can easily repeat the experiment on a small scale with tinfoil. [A thick piece of sheet lead from the lower buildings of Nelson's monument, Edinburgh, punctured by lightning, was exhibited. It is figured in the woodcut, reprinted (by permission) from *Proc.* R.S.E., 1863.]



Sheet-Lead Punctured by Lightning.

The name *thunderbolt*, which is still in use, even by good writers, seems to have been introduced in consequence of the singular effects produced when lightning strikes a sandhill or sandy soil. It bores a hole often many feet in length, which is found lined throughout with vitrified sand. The old notion was that an intensely hot, solid mass, whose path was the flash of lightning, had buried itself out of sight, melting the sand as it went down. It is quite possible that this notion may have been strengthened by the occasional observation of the fall of aerolites, which are sometimes found, in the holes they have made, still exceedingly hot. And at least many of the cases in which lightning is said to have been seen in a perfectly clear sky are to be explained in the same way. Everyone knows Horace's lines—

> "Diespiter
> Igni corusco nubila dividens
> Plerumque, per purum tonantes
> Egit equos volucremque currum."

But Virgil's remark is not so commonly known. He is speaking of prodigies of various kinds, and goes on:—

> "Non alias coelo ceciderunt plura sereno
> Fulgura; nec diri toties arsere cometae."

It is very singular that he should thus have associated comets and meteorites, which quite recent astronomical discovery has shown to have a common origin.

Another remarkable peculiarity, long ago observed, is the characteristic smell produced when lightning strikes a building or a ship. Thus, in the "Odyssey," Ulysses tells how his vessel suffered after the crew had killed the kine of Helios:—"In the same hour Zeus thundered, and cast his bolt upon the ship, and she reeled all over, and was filled with sulphur." This was, till comparatively recent times, the common belief; nowadays we know it to be mainly due to ozone. In fact, all the ready modes of forming ozone which are as yet at the disposal of the chemist depend upon applications of electricity. But besides ozone, which is formed from the oxygen of the air, there are often produced nitric acid, ammonia, and other compounds derived from the constituents of air and of aqueous

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vapour. All these results can be produced on a small scale in the laboratory.

Hitherto I have been speaking of lightning discharges similar in kind to the ordinary electric spark, what is commonly called *forked* or *zigzag* lightning. Our nomenclature is very defective in this matter, and the same may be said of the chief modern European languages. For, as Arago remarks, by far the most common form of lightning flash observed in thunderstorms is what we have to particularise, for want of a better term, as *sheet lightning*. He asserts that it occurs thousand-fold as often as forked lightning; and that many people have never observed the latter form at all! It is not at all easy to conceive what can be the nature of sheet lightning, if it be not merely the lighting up of the clouds by a flash of forked lightning not directly visible to the spectator. That this is, at least in many cases, its origin is evident from the fact that its place of maximum brightness often takes the form of the *edge* of a cloud, and that the *same* cloud-edge is occasionally lit up several times in quick succession. You will remember that we are at present dealing with the appearances observed *in* a thunderstorm, so that I do not refer to that form of sheet lightning which commonly goes by the name of *summer lightning*, and which is not, audibly at least, followed by thunder.

The next remarkable feature of the storm is the thunder, corresponding, of course, on the large scale to the snap of an electric spark. Here we are on comparatively sure ground, for sound is very much more thoroughly understood than is electricity. We speak habitually and without exaggeration of the *crash* of thunder, the *rolling* of thunder, and of a *peal* of thunder; and various other terms will suggest themselves to you as being aptly employed in different cases. All of these are easily explained by known properties of sound. The origin of the sound is in all cases to be looked for in the instantaneous and violent dilatation of the air along the track of the lightning flash; partly, no doubt, due to the disruptive effects of electricity of which I have already spoken, but mainly due to the excessive rise of temperature, which renders the air for a moment so briliantly incandescent. There is thus an extremely sudden compression of the air all round the track of the spark; and a less sudden, but still rapid, rush of the air into the partial vacuum which it produces. Thus the sound wave produced must at first be of the nature of a bore or breaker. But as such a state of motion is unstable, after proceeding a moderate distance the sound becomes analogous to other loud but less violent sounds, such as those of the discharge of guns. Were there few clouds, were the air of nearly uniform density, and the flash a short one, this would completely describe the phenomenon, and we should have a thunder *crash* or thunder *clap* according to the greater or less proximity of the seat of discharge. But, as has long been well known, not merely clouds but surfaces of separation of masses of air of different density, such as constantly occur in thunderstorms, *reflect* vibrations in the air; and thus we may have many successive echoes, prolonging the original sound. But there is another cause, often more efficient than these. When the flash is a long one, all its parts being nearly equidistant from the observer, he hears the sound from all these parts simultaneously; but if its parts be at very different distances from him, he hears *successively* the sounds from portions farther and farther distant from him. If the flash be much zigzagged, long portions of its course may run at one and the same distance from him, and the sounds from these arrive simultaneously at his ear. Thus we have no difficulty in accounting for the *rolling* and *pealing* of thunder. It is in fact a mere consequence, sometimes of the reflection of sound, sometimes of the finite velocity with which it is propagated. The usual rough estimate of five seconds to a mile is near enough to the truth for all ordinary calculations of the distance of a flash from the observer.

We now come to an exceedingly strange and somewhat rare phenomenon, to which the name of *fire ball* or *globe lightning* has been given. As we are as yet unable to produce anything of this kind by means of our electrical machines, some philosophers have tried to cut the Gordian knot of the difficulty by denying that any such thing can exist. But, as Arago says, "*Où en serions nous, si nous nous mettions à nier tout ce qu'on ne sait pas expliquer.*" The amount of trustworthy and independent evidence which we possess as to the occurrence of this phenomenon is such as must convince every reasonable man who chooses to pay due attention to the subject. No doubt there is a great deal of exaggeration, as well as much imperfect and even erroneous observation, in almost all of these records. But the existence of the main feature (the fire *ball*) seems to be proved beyond all doubt.

The most marked peculiarities of this species of lightning discharge are its comparatively long duration and its comparatively slow motion. While a spark, or lightning flash, does not last longer than about a millionth part of a second, if so long, globe lightning lasts from one to ten seconds, sometimes even longer, so that a sufficiently self-possessed spectator has time carefully to watch its behaviour. The general appearance is that of a luminous ball, which must be approximately spherical, because it always appears circular in outline, slowly and steadily descending from a thundercloud to the ground. It bursts with a loud explosion, sometimes before reaching the ground, sometimes as it impinges, and sometimes after actually rebounding. Its size varies from that of a child's head to a sphere of little less than a yard in diameter. On some occasions veritable flashes of lightning were seen to proceed from large fire balls as they burst. It is difficult to imagine what these balls can be if they be not a species of natural Leyden jar very highly charged. If it be so, no ordinary lightning rod can possibly prevent danger from it; and we may thus be able to explain the very few cases in which damage has been done by lightning to thoroughly protected buildings. To guard against this form nothing short of a pretty close network of stout copper wires would suffice. Meanwhile I give a brief sketch of *two* out of the long series of descriptions of such phenomena which Arago has patiently collected. The first is given on the authority of Babinet, who was deputed by the Academy of Sciences to make inquiries into the case.

Shortly, but not immediately, after a loud peal of thunder, a tailor who was sitting at his dinner saw the paper ornament which covered his fireplace blown down as if by a gentle breeze, and a globe of fire, about the size of a child's head, came gently out and moved slowly about at a slight elevation above the floor. It appeared bright rather than hot, and he felt no sensation of warmth. It approached him like a little kitten which desired to rub itself in play against his legs; but he drew his feet away, and by slow and cautious movements avoided contact with it. It remained several seconds near his feet, while he leaned forward, and carefully examined it. At last it rose vertically to about the level of his head, so he threw himself back in his chair and continued to watch it. It then became slightly elongated, and moved obliquely towards a hole pierced to the chimney about a yard above the mantel-piece. This hole had been made for the chimney of a stove which was used in winter. "But," as the tailor said, "the globe could not *see* the hole, for paper had been pasted over it." The globe went straight for the hole, tore off the paper, and went up the chimney. After the lapse of time which, at the rate at which he had seen it moving, it would have required to get to the top of the chimney, a terrific explosion was heard, and a great deal of damage was done to the chimney and roofs around it.

The next is even more striking: In June, 1849, in the evening of one of the days when cholera was raging most formidably in Paris, the heat was suffocating, the sky appeared calm, but summer lightning was visible on all sides. Madame Espert saw from her window something like a large red globe, exactly resembling the moon when it is seen through mist. It was descending slowly towards a tree. She at first thought it was a balloon, but its colour undeceived her; and whilst she was trying to make out what it was, she saw the lower part of it take fire ("*Fe vis le feu prendre au bas de ce globe*") while it was still some yards above the tree. The flames were like those of paper burning slowly, with sparks and jets of fire. When the opening became twice or thrice the size of one's hand a sudden and terrific explosion took place. The infernal machine was torn to pieces, and a dozen flashes of zigzag lightning escaped from it in all directions. The *débris* of the globe burned with a brilliant white light, and revolved like a catherine wheel. The whole affair lasted for at least a minute. A hole was bored in the wall of a house, three men were knocked down in the street, and a governess was wounded in the neighbouring school, besides a good deal of other damage.

As another instance, here is a description (taken from Dové) of one which fell at Barbadoes in 1831, during a terrific hurricane. At three o'clock in the morning the lightning ceased for a few moments, and the darkness which enveloped the town was indescribably terrible. Fiery meteors now fell from the clouds; one in particular, of spherical form, and of a deep red colour, fell perpendicularly from a considerable height. This fire ball fell quite obviously by its own weight, and not under the influence of any other external force. As with accelerated velocity it approached the earth it became dazzlingly white, and of elongated form. When it touched the ground it splashed all about like melted metal, and instantly disappeared. In form and size it resembled a lamp globe; and the splashing about at impact gave it the appearance of a drop of mercury of the same size.

I have never seen one myself, but I have received accounts of more than one of them from competent and thoroughly credible eye witnesses. In particular on a stormy afternoon in November, 1868, when the sky was densely clouded over, and the air in a highly electrical state, there was heard in Edinburgh one solitary short, but very loud, clap of thunder. There can be no doubt whatever that this was due to the explosion of a fire ball, which was seen by many spectators, in different parts of the town, to descend towards the Calton Hill, and to burst whilst still about a hundred feet or so above the ground. The various accounts tallied in most particulars, and especially in the very close agreement of the positions assigned to the ball by spectators viewing it from different sides, and in the intervals which were observed to elapse between the explosion and the arrival of the sound.

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The remaining phenomena of a thunderstorm are chiefly the copious fall of rain and of hail, and the almost invariable lowering of the barometer. These are closely connected with one another, as we shall presently see.

Almost all the facts to which I have now adverted point to water substance, in some of its many forms, as at least one of the chief agents in thunderstorms. And when we think of other tremendous phenomena which are undoubtedly due to water, we shall have the less difficulty in believing it to be capable of producing thunderstorms also.

First of all let us think of some of the more obvious physical consequences of a fall of a mere tenth of an inch of rain. Suppose it to fall from the lowest mile of the atmosphere. An inch of rain is 5lb. of water per square foot, and gives out on being condensed from vapour approximately 3,000 units of heat on the centigrade scale. The mass of the mile-high column of air a square foot in section is about 360lb., and its specific heat about a quarter. Thus its temperature throughout would be raised by about 33° C., or 60° F. For one-tenth inch of rain, therefore, we should have a rise of temperature of the lowest mile of the atmosphere amounting to 3·3° C., quite enough to produce a very powerful ascending current. As the air ascends and expands it cools, and more vapour is precipitated, so that the ascending current is farther accelerated. The heat developed over one square foot of the earth's surface under these conditions is equivalent to work at the rate of a horse-power for twelve minutes. Over a square mile this would be ten million horse-power for half an hour. A fall of one-tenth of an inch of rain over the whole of Britain gives heat equivalent to the work of a million millions of horses for half an hour! Numbers like these are altogether beyond the limits of our understanding. They enable us, however, to see the full explanation of the energy of the most violent hurricanes in the simplest physical concomitants of the mere condensation of aqueous vapour.

I have already told you that the source of atmospheric electricity is as yet very uncertain. Yet it is so common and so prominent a phenomenon in many of its manifestations that there can be little doubt that innumerable attempts have been made to account for it. But when we consult the best treatises on meteorology we find it either evaded altogether or passed over with exceedingly scant references to evaporation or to vegetation. This notion is due to Pouillet. Peltier suggested that the whole earth is permanently electrified. Not finding anything satisfactory in books, I have consulted able physicists, and some of the ablest of meteorologists, in all cases but one with the same negative result. I had, in fact, the feeling which every one must experience who attempts to lecture on a somewhat unfamiliar subject, that there *might* be much known about it which I had not been fortunate enough to meet with. Several years ago I was experimentally led to infer that mere *contact* of the particles of aqueous vapour with those of air, as they fly about and impinge according to the modern kinetic theory of gases, produced a separation of the two electricities, just as when zinc and copper are brought into contact the zinc becomes positively electrified and the copper negatively. Thus the electrification was supposed to be the result of chemical affinity.* Let us suppose, then, that a particle of vapour, after impact on a particle of air, becomes electrified positively (I shall presently mention experiments in support of this supposition), and see what farther consequences will ensue when the vapour condenses. We do not know the mechanism of the precipitation of vapour as cloud, and we know only partially that of the agglomeration of cloud particles into rain drops; but of this we can be sure that, if the vapour particles were originally electrified to any finite potential, the cloud particles would be each at a potential enormously higher, and the rain drops considerably higher still. For, as I have already told you, the potential of a free charged sphere is proportional directly to the quantity of electricity on it and inversely to its radius; so when eight equal and equally charged spheres unite into one sphere of double the radius, its potential is four times that of each of the separate spheres. The potential in a large sphere so built up is, in fact, directly proportional to its surface as compared with that of any one of the smaller equal spheres of which it is built.

Now, the number of particles of vapour which go to the formation of a single average rain drop is about 300 millions of millions of millions, so that the potential of the drop would be about 50 billion times as great as that of a particle of vapour. On the very lowest estimate this would be almost incomparably greater than any potential we can hope to produce by means of electrical machines.

But this attempt at explanation of atmospheric electricity presents two formidable difficulties at the very outset.

1. How should the smaller cloud particles ever unite if they be charged to such high potentials, which of course must produce intense repulsions between them?

* *Proc.*, R.S.E., 1875. In 1876 a somewhat similar idea was published by Luddens; but he ascribes the electrification to *friction* between air and water vapour.

2. Granting that, in spite of this, they do so unite, how are they separated from the mass of negatively electrified air in which they took their origin?

I think it is probable that the second objection is more imaginary than real, since there is no doubt that the diffusion of gases would speedily lead to a great spreading about of the negatively electrified particles of air from among the precipitated cloud particles into the less highly electrified air surrounding the cloud. And if the surrounding air were equally electrified with that mixed with the cloud, there would be no electric force preventing gravity from doing its usual work. This objection, in fact, holds only for the *final* separation of the whole moisture from the oppositely electrified air; and gravity may be trusted to accomplish this. That gravity is an efficient agent in this separation is the opinion of Professor Stokes. It must be observed that as soon as the charge on each of the drops in a cloud rises sufficiently, the electricity will pass by discharge to those which form the bounding layer of the cloud.

The first objection is at least partially met by the remark that in a cloud mass when just formed, if it be at all uniform, the electric attractions and repulsions would approximately balance one another at every point, so that the mutual repulsion of any two water drops would be almost compensated except when they came very close to one another.

But there is nothing in this explanation inconsistent with the possibility that the particles of water may be caused to fly about repeatedly from cloud to cloud, or from cloud to an electrified mass of air; and in many of these regions the air, already in great part deprived of its moisture, may have become much cooled by expansion as it ascends, so that the usual explanation of the production of hail is not, at least to any great extent, interfered with.

I may here refer to some phenomena which seem to offer, if closely investigated, the opportunity for the large scale investigations which, as I shall presently show, will probably be required to settle the source or sources of atmospheric electricity.

First, the important fact, well known nearly 2,000 years ago, that the column of smoke and vapour discharged by an active volcano gives out flashes of veritable lightning. In more modern times this has been repeatedly observed in the eruptions of Vesuvius and other volcanos—such as, for instance, the island of Sabrina. It is recorded by Sir W. Hamilton (British ambassador at Naples at the end of last century) that in the eruption of 1794 these flashes were accompanied by violent peals of thunder. They destroyed houses in the neighbourhood of the mountain, and are said to have done considerable damage even at places 250 miles off, to which the cloud of volcanic dust and vapour was carried by the wind. I will read a couple of extracts from Hamilton's paper. It is in the *Philosophical Transactions* for 1795:—

"The electric fire in the year 1779, that played constantly within the enormous black cloud over the crater of Vesuvius, and seldom quitted it, was exactly similar to that which is produced on a very small scale by the conductor of an electrical machine communicating with an insulated plate of glass, thinly spread over with metallic filings, &c., when the electric matter continues to play over it in zigzag lines without quitting it. I was not sensible of any noise attending that operation in 1779; whereas the discharge of the electrical matter from the volcanic clouds during this eruption, and particularly the second and third days, caused explosions like those of the loudest thunder; and, indeed, the storms raised evidently by the sole power of the volcano resembled in every respect all other thunderstorms, the lightning falling and destroying everything in its course. The house of the Marquis of Berio at S. Jorio, situated at the foot of Vesuvius, during one of these volcanic storms was struck with lightning, which, having shattered many doors and windows, and damaged the furniture, left for some time a strong smell of sulphur in the rooms it passed through. Out of these gigantic and volcanic clouds, besides the lightning, both during this eruption and that of 1779, I have, with many others, seen balls of fire issue, and some of a considerable magnitude, which, bursting in the air, produced nearly the same effect as that from the air balloons in fireworks, the electric fire that came out having the appearance of the serpents with which those firework balloons are often filled. The day on which Naples was in the greatest danger from the volcanic clouds, two small ball of fire, joined together by a small link like a chain shot, fell close to my *casino* at Posilipo. They separated, and one fell in the vineyard above the house, and the other in the sea, so close to it that I heard a splash in the water; but, as I was writing, I lost the sight of this phenomenon, which was seen by some of the company with me, and related to me as above."

"The Archbishop of Taranto, in a letter to Naples, and dated from that city the 18th of June, said, 'We are involved in a thick cloud of minute volcanic ashes, and we imagine that there must be a great eruption either of Mount Etna or of Stromboli.' The bishop did not dream of their having proceeded from Vesuvius, which is about 250 miles from Taranto. We have had accounts also of the fall of the ashes during the late eruption at the very

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extremity of the province of Leece, which is still farther off; and we have been assured likewise that those clouds were replete with electrical matter. At Martino, near Taranto, a house was struck and much damaged by the lightning from one of these clouds. In the accounts of the great eruption at Vesuvius in 1631 mention is made of the extensive progress of the ashes from Vesuvius, and of the damage done by the *ferilli*, or volcanic lightning, which attended them in their course."

Sabine, while at anchor near Skye, remarked that the cloud cap on one of the higher hills was permanently luminous at night, and occasionally gave out flashes resembling those of the aurora. I have not been able to obtain farther information as to this very important fact; but I have recently received a description of a very similar one from another easily accessible locality.

My correspondent writes from Galway, to the following effect, on the 2nd of January, 1880:—

"At the commencement of the present unprecedentedly long and severe storm the wind blew from south-west and was very warm. After blowing for about two days it became, *without change of direction*, exceedingly bitter and cold, and the rain was, from time to time, mixed with sleet and hail, and lightning was occasional. This special weather is common for weeks together in March or early April. The air is (like what an east wind brings in Edinburgh) cold, raw, dry, and in every way uncomfortable, especially to people accustomed to the moist Atlantic winds. During these weeks series of small clouds, whose shadows would only cover a field of a few acres, seem to start at regular intervals from the peaks of hills in Connemara and Mayo. They are all more or less charged with electricity. From high ground, behind the city, I have at one time seen such a cloud break into lightning over the spire of the Jesuits' church. At another I have seen such a cloud pour down in a thin line of fire, and fall into the bay in the shape of a small incandescent ball. On one occasion I was walking with a friend, when I remarked, 'Let us turn and make a run for it. We have walked unwittingly right underneath a little thundercloud.' I had scarcely spoken when a something *flashed on the stony ground at our very feet*, a tremendous crash pealed over our heads, and the smell of sulphur was unmistakable. I fancy that I have been struck with these phenomena more than others, from the circumstance that they have always interfered with my daily habits. My walks extended to great distances and to very lonely districts. Now, these small local spurts of thunderstorms would hardly excite attention in the middle of a town, all the less as the intervening weather is bright, though raw—these spurts coming on every three or four quarters of an hour. Neither would they excite much attention in the country, as, while such a little storm was going on in one's immediate neighbourhood, you would see at no great distance every sign of fine weather. In fact they always seem to me like the small change of a big storm."

My correspondent, though a good observer and eloquent in description, is not a scientific man. But it is quite clear from what he says that a residence of a few weeks in Galway, at the proper season, would enable a trained physicist to obtain, with little trouble, the means of solving this extremely interesting question. He would require to be furnished with an electrometer, a hygrometer, and a few other simple pieces of apparatus, as well as with a light suit of plate armour, not of steel, but of the best conducting copper, to insure his personal safety. Thus armed he might fearlessly invade the very nest or hatching place of the phenomenon, on the top of one of the Connemara hills. It is to be hoped that some of the rising generation of physicists may speedily make the attempt, in the *spirit* of the ancient chivalry, but with the offensive and defensive weapons of *modern* science.

Another possible source of the electricity of thunderstorms has been pointed out by Sir W. Thomson. It is based on the experimental fact that the lower air is usually charged with negative electricity. If ascending currents carry up this lower air the electricity formerly spread in a thin stratum over a large surface may, by convection, be brought into a very much less diffused state, and thus be raised to a potential sufficient to enable it to give a spark.

However the electrification of the precipitated vapour may ultimately be accounted for, there can be no doubt of the fact that at least as soon as *cloud* is formed the particles are electrified; and what I have said as to the immense rise of potential as the drops gradually increase in size remains unaffected. I have tried various forms of experiment, with the view of discovering the electric state of vapour mixed with air. For instance, I have tested the vapour which is suddenly condensed when a receiver is partially exhausted; the electrification of cooled bodies exposed to moist air from a gasholder; and the deposition of hoar frost from a current of moist air upon two polished metal plates placed parallel to one another, artificially cooled, and connected with the outer and inner coatings of a charged jar. All have given results, but as yet too minute and uncertain to settle such a question. These experiments are still in progress. It appears probable, so far, that the problem will not be finally solved until experiments are made on a scale much larger than is usual in laboratories. Kalischer has quite recently attempted to disprove this theory, but his experiments are all liable to the same objection, they were made on much too small a scale.

A great thunderstorm in summer is in the majority of cases preceded by very calm sultry weather. The atmosphere is in a state of unstable equilibrium, the lower strata are at an abnormally high temperature, and highly charged with aqueous vapour. It is not easy, in a popular lecture like this, to give a full account of what constitutes a state of stable equilibrium, or of unstable, especially when the effects of precipitation of vapour are to be largely taken into account. It is sufficient for my present purpose to say that in all cases of thoroughly stable equilibrium, a slight displacement *tends to right itself;* while, in general, in unstable equilibrium, a slight displacement tends to increase. Now, if two cubic feet of air at different levels could be suddenly made to change places, without at first any other alteration, and if, on being left to themselves, each would, under the change of pressure which it would suddenly experience, and the consequent heating or cooling, with its associated evaporation or precipitation of moisture, tend to regain its former level, the equilibrium would be stable. This is not the case when the lower strata are very hot, and fully charged with vapour. Any portion accidentally raised to a higher level tends to rise higher, thus allowing others to descend. These, in consequence of their descent, tend still further to descend, and thus to force new portions up. Thus, when the trigger is once pulled, as it were, we soon have powerful ascending currents of hot moist air, precipitating their moisture as cloud as they descend, cooling by expansion, but warmed by the latent heat of the vapour condensed. This phenomenon of ascending currents is strongly marked in almost every great thunderstorm, and is precisely analogous to that observed in the centre of a West Indian tornado and of a Chinese typhoon.

When any portion of the atmosphere is ascending it must be because a denser portion is descending, and whenever such motions occur *with acceleration* the pressure must necessarily be diminished, since the lower strata are not then supporting the whole weight of the superincumbent strata. If their whole weight were supported they would not descend. Thus even a smart shower of rain must directly tend to lower the barometer. [A long glass tube, filled with water, was suspended in a vertical position by a light spiral spring, reaching to the roof of the hall. A number of bullets hung at the top of the water column, attached to the tube by a thread. When the thread was burned, by applying a lamp, the bullets descended in the water, and *during their descent* the spring contracted so as to raise the whole tube several inches.]

In what I have said to-night I have confined myself mainly to *great* thunderstorms, and to what is seen and heard by those who are within their sphere of operation. I have said nothing of what is commonly called *summer lightning*, which is probably, at least in a great many cases, merely the faint effect of a distant thunderstorm, but which has also been observed when the sky appeared tolerably clear, and when it was certain that no thunderstorm of the ordinary kind had occurred within a hundred miles. In such cases it is probable that we see the lightning of a storm which is taking place in the upper strata of the atmosphere, at such a height that the thunder is inaudible, partly on account of the distance, partly on account of the fact that it takes its origin in air of small density.

Nor have I spoken of the aurora, which is obviously connected with atmospheric electricity, but in what precise way remains to be discovered. Various theories have been suggested, but decisive data are wanting. Dr. Balfour Stewart inclines to the belief that great auroras, visible over nearly a whole terrestrial hemisphere, are due to inductive effects of changes in the earth's magnetism. This is not necessarily inconsistent with the opinion that, as ordinary auroras generally occur at times when a considerable change of temperature takes place, they are phenomena due to the condensation of aqueous vapour in far less quantity, but through far greater spaces, than the quantities and spaces involved in ordinary thunderstorms.

We now *know* that electricity is not a substance; the "electric fluid" is only read of in the reports of penny-a-liners. But if it be a form of energy due to stresses in the luminiferous medium, how do we account for the fact that positive and negative electricity are always developed simultaneously in *equal* quantities?

We can form a rough analogy thus:—Take hold of the middle of a stretched rope and twist it. Whatever amount of twist is thus given to one end, *exactly* as much untwisting is simultaneously given to the other. Or even more simply. Take a stretched india rubber string firmly by the middle, and move your hand towards either end. That end is *relaxed* and the other simultaneously extended to equal amounts.

Thus there is nothing to hinder us from supposing that a distorsion of any kind in the ether may *necessarily* be accompanied by an *equal* and *opposite* distorsion of a similar kind, though the exact mechanism of the process may long elude the intellects of the greatest philosophers.

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ANSWERS TO CORRESPONDENTS.

NON-GULLER OF THE PUBLIC.—*We shall have pleasure in inserting your letter if we may append your name to it.*

J. CHAPMAN.—*The chapter on Electro-Metallurgy of Mr. Sprague's book cannot be obtained separately, but it may be possible to obtain a second-hand copy of the first edition at a low price. Watts's "Electro-Metallurgy" is likely to be the most suitable for you. The way to use aqua fortis depends on the required purpose, as it must be diluted to strengths suitable for cleansing different metals. But it is usual to just dip the object in strong aqua fortis for a moment as a finishing preparation before beginning to coat, in order to produce a surface best suited for adhesion. It should not be used with substances of the nature of pewter or Britannia metal, which should be cleaned with alkalis.*

CONTENTS.

Notes ... 121
Electro-Chemistry. By Dr. G. Gore. (Continued) ... 126
Correspondence ... 127
Thunderstorms. By Professor Tait. (Concluded.) Illus... 128
The Post Office and the Telephone ... 132
The Induction of Currents in Cores. By Oliver Heaviside. (Continued) ... 133
Electricity and Light.—III. By John T. Sprague ... 135
Moseley's Improvements on Blake Transmitters ... 136
The Installation at Colchester Illustrated ... 137
Volta and Magneto Electric Induction. By Willoughby Smith. Illustrated ... 138
Legal ... 142
Companies' Meetings—
The Faure Electric Accumulator Company ... 144
Companies' Share List ... 144
Traffic Receipts ... 144

THE POST OFFICE AND THE TELEPHONE.

When we penned our article on the subject of Telephone Companies' grievances a fortnight ago we had no idea that we were meeting the forces of an organised army doing battle for the interests of the companies against the rights of the Post Office. But so it would seem; for if the usual indications are to be trusted, the press has been set on to badger the Postmaster-General, and the usual methods employed in the lobbies to bring parlimentary influence to bear upon him. The object is not precisely stated. But we can take our choice; either it is to obtain complete independence, or to force a State purchase. There can be no object except one of these two. Ostensibly the agitation is being got up with a view to the former, but as the promoters may be credited with some sense it is not to be supposed that they expect to succeed, and it follows that their ulterior aim is to get themselves bought up. Now, so far as anything we have said, or are about to say, is concerned, the question of purchase does not come before us. When the companies frankly avow their object we may discuss it; meanwhile we make them a present of the admission that we have no objection to the telephone business being taken over by the State, and rather regret that this was not done in the first instance. What the bargain should be is a different matter; and what we particularly take exception to at present are the methods adopted to exaggerate the companies' importance and swell the value of what they have to sell. Their own manifesto, although illogical and full of erroneous assumptions, is moderate in its tone; but it is evident that the lines of argument and material worked up by the press in support of the document are utterly untrustworthy and studiously offensive. An article in the *Edinburgh Courant* of June 5th is a notable sample of this, and it has been reprinted apparently for general circulation. *The Times* a week later published a similar article, quite as objectionable in its manner, and if possible more ridiculous in argument. Let us see what these two typical utterances amount to.

It is alleged by the *Courant* that the action of the Postmaster-General is defended on the ground that, having paid ten millions for the telegraphs, it is necessary to protect the telegraph revenue. Would the ground be different, we may ask, if the price had been less? It is usual to protect public revenue against all kinds of smuggling, and this on purely financial grounds, quite distinct from what the right to do so may have originally cost. *The Times* goes further, and roundly asserts that the permanent officials of the Post Office are personally interested in maintaining the revenue of the telegraph because they were responsible for its being purchased at an extravagant price. We look in vain for evidence in support of this scandalous charge against a body of public servants who are unable to defend themselves. There is absolutely no evidence of the kind; the outcry, in fact, being merely the echo of political teaching, which of late has taken views on the rights of property differing materially from those which prevailed when the purchase was made. However, it is pleasant to note that extravagant bargains are not in favour with the friends of the telephone companies. It is to be hoped they will stand firmly to their principles if ever another transaction of a like kind comes on for discussion.

But, says the *Courant*, the apprehension of loss of revenue is altogether "hollow and misleading." The telephone and the telegraph are "not competitors," but "healthy rivals," the effect of whose rivalry is "to increase the demand for both facilities." Statistics are mentioned as bearing out this courageous assertion, but they are not given, and we confidently assert that they cannot be produced, for the simple reason that they involve a contradiction, the very essence of such a rivalry being to absorb and transfer the rival's business, not to increase it. At all events this is obviously the case in respect to a rivalry between telegraph and telephone, for whichever system is found most convenient will send the other to the wall. One chief grievance of the companies is that the Post Office will not let them, without paying an equitable price for it, do business which would wipe out any remaining distinction between telephony and telegraphy. Let us, say the companies, connect large towns by trunk lines. By all means, reply the Post Office, but you must pay for it if you do, for we do not believe—nobody believes—in your pretence that it would increase our business; on the contrary, it would damage it to the extent of your gain, and more. Either, therefore, you must pay for such an unlooked for concession—a concession which was never dreamed of when our bargain was first made—or we ourselves will make the trunk lines

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when we see the public demand for it. As regards the proposal to connect private customers with telegraph offices by means of the telephone, the only proposal which looks like feeding the telegraph by "increasing the demand for facilities" would in reality be affording undue facilities to private individuals, and, as affecting the delivery of telegrams, contrary to the spirit of the Telegraph Acts. What the companies were really driving at had they "been left free to develop their business in their own way" is graphically set forth in *The Times* article: "There would by this time have been arrangements by which in every town in the kingdom any one might have gone into the office, might have been placed in direct communication with any other person in the same or in any other town, and have been enabled for a small charge to converse with him unrestrictedly." We need not waste words on the fancy sketch of our leading organ; but this we may say, if it is in any sense a true picture of what might have happened, to make the tableau complete, the wreck of the postal telegraphs ought to be added in the background, with ten millions of public money buried under the ruins.

But the money loss, we are told, is as nothing compared to the moral delinquency of the Postmaster-General. *The Times* is overflowing with morality on this topic. We should have thought that for clients who deliberately started an opposition which they perfectly well knew could not be sustained either in law or equity the less said about morality the better. But according to *The Times* it was immoral of the Post Office to accept the verdict of a court of law and not go to Parliament to get it reversed. It is immoral to deprive inventors of the fruits of their discovery—that is to say if the Post Office is the guilty party—but apparently not if the shareholders of a big company have committed the wrong. Some inventors have certainly suffered, but their complaints have not been directed exclusively or even chiefly against the Post Office. Lastly, it was immoral to claim the telephone as a telegraph, because "the principle on which the telephone rests is entirely different from that of the telegraph." So, too, does the locomotive differ in principle from that of the mail coach. The moral question, we should have thought, comes in with the burden to be carried. The Postmaster-General did not abdicate his exclusive right to carry letters because somebody else invented a faster conveyance for them; nor is it likely that Mr. Fawcett will betray his duty to the country in obedience to a new code of ethics invented for the sole benefit of "healthy rivals."

THE INDUCTION OF CURRENTS IN CORES.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 104.)

Induction in a Divided Core.

To ascertain under what circumstances the heating, according to Joule's law, of a properly divided core might become sensible—general considerations telling us that it must be very small—let us, to bring the matter under mathematical treatment, specify a particular manner of division. This will be most shortly described by referring to a plane section of the core perpendicular to its axis. Divide the circular section by radii into sectors, and let the sectors be of two sets, one set having all an opening of say 1°, and the other set of say 9°. These are to alternate. The small sectors to be filled up with dielectric material, the large with metal. We thus stop the free flow of the circular induced currents in the core by the insulating barriers placed perpendicular to the lines of E.M.F. There are 36 condensers (the number is immaterial), joined up in sequence, which become charged and discharged during the passage of an oscillatory current in the coil circuit, and according to old notions electricity accumulates on the bounding surfaces of the condensers. According to Maxwell's views, however, the currents flow in the same closed circuits as if the core were solid metal, but in the dielectric portions the electric elasticity brings a counter E.M.F. into play, thus preventing the passage of a continuous current, and weakening the strength of oscillatory currents.

Let ρ_1 and c_1 be the resistance and the electrostatic capacity per unit volume of the compound core, later more particularly defined. Let e, as before, be the impressed force per unit length arising from electro-magnetic induction, γ the current density, and now, in addition, D the electric displacement per unit area perpendicular to the lines of flow. Then, instead of the former equation, $e=\rho\gamma$, we shall have

$$e=\rho_1\gamma+\mathrm{D}/c_1 \qquad (55)$$

with the additional relation

$$\gamma=\dot{\mathrm{D}} \qquad (56)$$

Differentiating equation (55) to t, and getting rid of D, by (56), we obtain

$$c_1\dot{e}=c_1\rho_1\dot{\gamma}+\gamma \qquad (57)$$

which we must substitute for the old $e=\rho\gamma$.

Equation (10) holds as before, connecting the current and the magnetic force. So does equation (12), giving the E.M.F. of induction, if we give to μ therein a new value, to be given presently, on account of the core not being homogeneous. Eliminating e between equations (57) and (12) we obtain

$$\frac{1}{r}\frac{d}{dr}r\frac{d}{dr}(\dot{\mathrm{H}}+\mathrm{H}/\rho_1c_1)=\frac{4\pi\mu}{\rho_1}\ddot{\mathrm{H}} \qquad (14a)$$

instead of equation (14) for the characteristic equation of magnetic force in the compound core. Its solution, suitable for oscillatory currents, requires the use of two functions of r, say H_1 and H_2, satisfying

$$\left.\begin{aligned}\frac{1}{r}\frac{d}{dr}r\frac{d}{dr}(\mathrm{H}_1+\mathrm{H}_2/\rho_1c_1)&=-x_1\mathrm{H}_2\\ \frac{1}{r}\frac{d}{dr}r\frac{d}{dr}(\mathrm{H}_2+\mathrm{H}_1/\rho_1c_1)&=+x_1\mathrm{H}_1\end{aligned}\right\} \qquad (22a)$$

instead of equations (22). Here x_1 stands for $4\pi\mu/\rho_1$. And H_1 and H_2 may be found in series of ascending powers of r by

$$\left(\frac{1}{r}\frac{d}{dr}r\frac{d}{dr}+\frac{1}{\rho_1c_1}\right)^2\mathrm{H}_1=-x_1^2\mathrm{H}_1 \qquad (23a.)$$

which takes the place of (23).

Now as regards ρ_1, c_1, and μ_1. If the ratio of the angles of the wedges occupied by conducting and insulating material be n_1/n_2, and $n_1+n_2=1$, we shall have, if ρ be the specific resistance of the conductor,

$$\rho_1=n_1\rho,$$

the specific resistance of the compound core becoming somewhat reduced. And, if μ_1 and μ_2 be the magnetic permeabilities of the conducting and dielectric parts of the core, we have

$$\mu=n_1\mu_1+n_2\mu_2,$$

giving the value of μ to be used in equation (12) and in (14a) just given. Thus the permeability of the compound core, if the conducting part be of iron, is somewhat reduced.

Lastly, if c be the electrostatic capacity per unit volume of the dielectric only, that of the compound core is

$$c_1=c/n_2.$$

The time constant ρ_1c_1 which appears in the characteristic equation (14a) is thus given by

$$\rho_1c_1=\rho cn_1/n_2,$$

where ρ and c belong to the metal and dielectric separately, ρ_1 and c_1 to the compound. The value of this time constant is the same whether there are 20 or 20,000 wedges, alternately metal and dielectric, provided the ratio n_1/n_2 of the spaces they occupy, which appears in the last equation, is kept the same.

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But this time interval must in general be extremely small. For c the electrostatic capacity of unit volume of the dielectric is $K/4\pi$ in electrostatic measure, K being the dielectric constant, and, in the electro-magnetic measure here required, we must further divide by V^2, where V is the velocity of light, $= 3 \times 10^{10}$. Thus we have

$$\rho_1 c_1 = \rho K n_1 / 4\pi V^2 n_2 ;$$

and K being a small number, and also $\rho = 10,000$ for iron, whilst V^2 is very large, $\rho_1 c_1$ must be very small, unless we make n_1/n_2 extravagantly large—*i.e.*, reduce the thickness of the dielectric wedges greatly, compared with that of the conducting wedges, which of course has the effect of increasing the capacity of the condensers. If this impracticable thinness of dielectric could be carried out with proper insulation, we should, with an oscillatory current in the coil, make the induced currents in the core less by as little as we pleased from what they would be in a solid conducting core, and the heating of the compound core similarly approach that of the solid one.

The influence of increased speed may also be noticed. Consider a single closed circuit of conductors and condensers in series, such as we obtain by confining ourselves to the portion of core contained between the cylinders of radii r and $r+1$. If we further take only the unit length parallel to the axis, the section of the circuit has the unit area. R being the resistance of the circuit, viz., the sum of the resistances of the conducting portions; and C its capacity, viz., the reciprocal of the sum of the reciprocals of the capacities of the single condensers, we have

$$E = R\gamma + Q/C,$$

similarly to (55), E being the total impressed force in the circuit, γ the current, and Q the common charge of each condenser. Also $\gamma = \dot{Q}$, whence

$$C\dot{E} = RC\dot{\gamma} + \gamma.$$

Now let the E.M.F. be of the simple harmonic type E sin nt, where E is constant; the solution for the current is then

$$\gamma = \frac{nCE}{\{1 + (nCR)^2\}^{\frac{1}{2}}} \cos(nt - \tan^{-1} nCR),$$

and the heat developed per second in the conducting part of the circuit is

$$\frac{\frac{1}{2}R(nCE)^2}{1 + (nCR)^2} = \frac{1}{2}\frac{E^2}{R}\left\{ 1 + (nCR)^{-2} \right\}^{-1}.$$

Here $\frac{1}{2}E^2/R$ is what the heating would be if the condensers were short circuited; so, from the value of nCR we can easily see how much it is reduced by the insertion of the condensers. The value of RC is the same as that of $\rho_1 c_1$ before given; also $n = 2\pi v$, v being the wave frequency. By sufficiently increasing the speed we may make the heating approach as nearly as we like to $\frac{1}{2}E^2/R$ without necessarily making the dielectric portions of the circuit excessively thin; but it may be readily seen that for the heating in the closed circuit of condensers to be comparable with what it would be were they short circuited, or the dielectric removed and conducting matter substituted, the frequency v must, on account of the presence of V^2 in the expression for RC, be itself comparable with the frequency of light vibrations. If, then, a properly divided iron core with oscillatory currents, or with such super-imposed on a steady current passing in a coil surrounding it, should become sensibly heated, such heating cannot have arisen from the Joule effect of the induced currents.

Transmission of Energy into a Conducting Core.

The magnetic energy per unit volume being $\mu H^2/8\pi$, where H is the magnetic force as before, if we suppose the magnetisation to be wholly induced, the magnetic energy per unit length of core of radius r is given by

$$\frac{\mu}{8\pi}\int 2\pi r dr . H^2 = \frac{\mu}{4}\int H^2 r dr \quad . \quad . \quad . \quad (58)$$

Also the rate of dissipation of energy in the same portion, being $\rho\gamma^2$ per unit volume, is given by

$$2\pi\rho\int \gamma^2 r dr = \frac{\rho}{8\pi}\int H'^2 r dr \quad . \quad . \quad . \quad . \quad (59)$$

since $\gamma = -H'/4\pi$. Now, energy can only enter the portion of core considered across its boundary, and, after having entered, is either stored up temporarily as magnetic energy, or is dissipated as heat through induced currents. Hence the rate of passage of energy into the space from outside equals the sum of the rate of increase of magnetic energy and of the rate of dissipation within the space. Thus, if by W we denote the amount of energy entering the core per second per unit area of its bounding surface, we obtain, by (58) and (59),

$$2\pi r W = \frac{\mu}{2}\int H\dot{H} r dr + \frac{\rho}{8\pi}\int H'^2 r dr$$

Here, by equation (14),

$$\dot{H} = \frac{\rho}{4\pi\mu r}\frac{d}{dr}(rH').$$

Making the substitution and integrating, we get

$$W = \frac{\rho}{4\pi\mu}\frac{dT}{dr} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (60)$$

where $T = \mu H^2/8\pi$, the magnetic energy per unit volume. From this we see that the transmission of energy takes place from places of greater to places of less force irrespective of sign, and that the rate of transference per second is proportional to the rate of decrease of the density of the magnetic energy in the direction of transference.

This remarkably simple property, which applies to every part of the core at every moment, according to which the transmission of magnetic energy whilst induced currents are lasting is determined solely by the space variation of its density, is not a general property of induction in conductors. If we inquire what the corresponding property is in general, by examining the rate at which energy is entering any given portion of a conductor through the imagined surface separating it from the rest, such being equal to the sum of the rate of increase of the magnetic energy and of the rate of dissipation as heat by induced currents within the portion considered, using the general relations

$$\text{curl } H = 4\pi\gamma, \text{ and } V^2 H + 4\pi\mu\dot{H}/\rho = 0,$$

we find that W_s, the rate of passage of energy at any point across the surface whose normal has any direction s per unit areas, or, briefly, the rate of transference in the direction s equals $\rho/4\pi$ times the component along s of the vector product of the current density and the magnetic force at the point. Or

$$W_s = \frac{\rho}{4\pi} V\gamma H$$

in the brief quaternion form. The direction of maximum transference is therefore perpendicular to the plane containing the magnetic force and the current directions, and its amount per second proportional to the product of their strengths and to the sine of the angle between their directions.

Eliminating the current, and expressing the relation in terms of magnetic force only, we find

$$W_s = -\frac{\rho}{4\pi\gamma}\frac{dT}{ds} + \frac{\rho}{(4\pi)^2} H \frac{dH_s}{dh} \quad . \quad . \quad . \quad (61)$$

where T is, as before, the density of the magnetic energy, H_s the component of H in the direction s, and h the direction of H itself.

Now, if we confine H to a constant direction, so that it cannot vary in strength in that direction, its component in any other direction s also does not vary along h. Then (61) reduces to

$$W_s = -\frac{\rho}{4\pi\mu}\frac{dT}{ds},$$

of which (60) is a special case.

(TO BE CONTINUED.)

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ELECTRICITY AND LIGHT.—III.

BY JOHN T. SPRAGUE.

(CONTINUED FROM PAGE 82.)

22. *Sounds are produced by energy* transmitted by undulations in the air or other substance, exactly as the energy is transferred by wave motion from the centre of a water pool; but the undulations are of a different order. There is no real difference, however. The fact is simply due to the different forces which resist the motion. The wave of water is a *vertical rise and fall*, because it is generated against the force of gravitation, and in a medium which has its weakest resistance on its surface. Therefore the motion of the molecules of water must needs occur in the line of least resistance and greatest force, and the energy is propagated at right angles to the undulation.

23. But sound being propagated in a uniform medium, as the air, which presents no direction of least resistance, and not against an active force, but against the elastic power of the medium itself, the result is a succession of pressures and reactions, which result in a series of spherical condensations and rarefactions—that is to say, undulations in the line of transmission. The conditions really resemble those of the line of billiard balls (Secs. 11 and 17). This involves no difference of principle, but merely a result of similar action under different conditions; and the pendulum, which as stated (Sec. 20) is the elementary type of all wave motion, presents both forms of undulation to the eye, as it shows true wave motion in its rise and fall, and the alternating form by its to and fro swing across its line of rest.

24. *The transmission of mechanical energy by sound* is easily exhibited. A single sound is of the nature of a blow such as would be transmitted by one rise and fall of the pendulum if allowed to strike another, or exactly like the motion of the last ball of the row (Sec. 11). Such a sound is illustrated by the stroke of a woodcutter's axe, which may be heard after the stroke itself is seen by a space of time dependent on the distance, sound travelling in air at the rate of 1,120 feet per second at ordinary temperature (62° F.), while light traverses some 185,000 miles per second. Now, if we have a room with two doors, one opening outwards, or with a hinged window, the sharp opening of one door will force the other open if not fastened; the elastic air in fact propagates the energy across the room just as a rigid bar would do. Again, if a stretched membrane, such as a tambourine, be supported on a stand, it will be found to vibrate to any sound, being literally struck by the waves of sound; the same also may be felt in a sheet of paper held in the hand.

25. *The perception of sound* is exactly of this nature. It is effected by a delicate organ of *touch* rather than of a special sense, for the ear consists really of the tambourine connected to a series of rods tuned to vibrate to their corresponding rates of wave motion, and so to transfer the mechanical energy carried in the portion of the waves which enter the ear into a succession of vibrations to be perceived by the special nerve arranged to transform those purely mechanical vibrations into mental perceptions. Of this stage we know nothing whatever; we can trace the transfer of energy up to the nerve, but how it is translated into perception we are utterly ignorant of, as of the process of all mental operations. But the point to which we have now come is the clear recognition that *sound itself has no existence*; in the air it is merely a motion of the particles of air, a transfer of radiant mechanical energy. This only *becomes sound in the ear itself* in the act of appreciation of the nature of the transmitting motion, and particularly of the rate of the undulations set up.

26. *Musical notes* are distinguished from other sounds as being caused by the continuation of a definite rate of undulation, the production of this being controlled by the conditions of the generator and the action and reaction of the force and resistance. The rate of swing of a pendulum is controlled by the length of the rod and the force of gravitation at the spot. We have seen that the swing of the pendulum is the type of all wave motion, and so also the length of the pendulum rod is the type of the production of musical sounds, that is of the wave length of notes. Thus a double length gives a double wave length or period of undulation, and notes which "harmonise" together and form "chords" agreeable to the ear are those whose rates are exactly proportioned to each other's intervals, while "discords" are produced by notes whose rates do not unite as definite proportionals. The length of a cord under a fixed strain, such as a piano wire, answers to the length of the pendulum, and produces the corresponding undulation in the air by vibration under a stress and the reacting elasticity of the cord.

27. *The musical scale* is a system of proportioned wave lengths or times so related as to please the sense of hearing, because based upon the mathematical relations of the intervals. It may be commenced upon any rate of vibration selected, but its intervals must hold the fixed relations. The number of vibrations which represents the note written on the second space, or the treble C or Do, is the "pitch," which varies from 424 to 440 per second; but whatever this is the relations among the several notes are—

Do	Re	Me	Fa	Sol	La	Si	Do
C	D	E	F	G	A	B	C
1	$\frac{9}{8}$	$\frac{5}{4}$	$\frac{4}{3}$	$\frac{3}{2}$	$\frac{5}{3}$	$\frac{15}{8}$	2
440	495	550	$586\frac{2}{3}$	660	$733\frac{1}{3}$	825	880

Thus a musical *octave* represents the interval in which the rate of vibration is doubled, each note having its rate doubled in the next higher octave.

The lowest sound recognised by the ear as a definite musical note has a rate of 27 per second, and the highest about 3,520. These are the ranges of a 7-octave piano, though *sounds* may be heard of lower rate and up to about 24,000.

28. *Notes are absorbed and reproduced by agencies which can produce them.* Thus, each glass tumbler or lamp-shade has a note proper to itself, as a bell has; and they will sound this note when an instrument or singer produces it. So also the wires of a piano will take up and sound each its own notes. They will also be sounded by their harmonics, though not so strongly. So powerful is this faculty for absorption, that it is quite possible to split a glass by singing its proper note strongly. It is this faculty of taking up a sounding body's specific vibration that was utilised in the harmonic telegraphs of Gray, La Cour, and others whose experiments preceded, and ultimately led to the invention of, the telephone. All of these depended on the intermission of currents produced by musical sounders, such as tuning forks, each producing its own rate of intermission. The receivers consisted of similar musical sounders under the influence of electro-magnets actuated by the current, so that only those would sound which corresponded to those which acted as transmitters.

29. *Interference* is the mutual action of two wave systems. In the pond of water (Secs. 17 and 21), the waves are reflected from the edges in circles which cross the original ones, or two distinct systems may be originated by two stones. It will be seen that however numerous the wave circles may be, they do not interfere with each other in the ordinary sense of the word; that is they do not interrupt each other's course, or in the least degree modify each other's form. But where they cross, the particles of water are compelled to take part in two or many distinct motions, and the result may be that at the point of intersection the wave may rise or sink to the sum of the two waves if they coincide; or if they are opposed the water level may be normal and motionless while transmitting a rising and a falling wave in different directions. This is what is called *interference*, and the result is that in the case of sound two loud notes may result in silent intervals, and in the case of light two strong lights may produce darkness.

Both these effects are easily observed; the *beats* in musical sounds are due to interference. They may be heard in a double-wire piano if badly tuned, and very strongly in a concertina with what is called the *voix celeste*, which is produced by two reeds with a small difference, resulting in a rising and falling sound. Any door will exhibit the same effect in light, for if opened so that a beam of light passes through the

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narrow opening at the back an apparent grating will be seen on the floor in the form of radial lines of light and shade. These are *diffraction* lines caused by the *interference* of the two rays of light reflected angularly through the slit from the two sides of the opening.

30. *Light reproduces all the phenomena,* and we are thus enabled to rise to the more occult principles of the generation and distribution of light by the study of sound, and the rough mechanical effects to be observed in pools of water, in stretched ropes, and in billiard balls. These enable us to see distinctly actions which unquestionably occur in the agents which produce and transmit light, but which cannot themselves be seen.

Light, like sound, has no specific existence; it is an undulatory action of energy set up in its generators and propagated, like sound, in rays and spherical waves, which in space are not light, nor even luminous; they only become light when transformed into a specific sensation in suitable organs—that is to say, *light is not a thing, but a perception of an action of energy.* The recognition of this is of great importance, because it involves the recognition of a fact by no means generally known, that *light can have no mechanical equivalent,* though the energy which produces the effect of light has such an equivalent. For this reason the same equivalent of energy expended by two sources of light, and delivering equal energy even to the very eye itself, may yet produce wholly different light effects, and therefore differ greatly in economy of light production.

MOSELEY'S IMPROVEMENTS ON BLAKE TRANSMITTERS.

It is well known that Blake's improvement on Edison's transmitter is the most approved of all telephone transmitters. It is not so widely known that there are three weak points in it which have hitherto been regarded as so inseparable from the Blake system that the most experienced telephone managers have for special purposes fallen back upon the original Edison and other instruments.

The reasons for this compulsory resort to anterior inventions are these:—

Firstly. There is no provision to exclude the fine dust incessantly floating about in every dry atmosphere, but which in all towns and cities is so profuse that it penetrates every cavity to which there is access through any crack or crevice, however fine. The electric current attracts this dust between and around the point of contact on the carbon button until in a few weeks at the least the articulation of the voice becomes so muffled and broken up by the transmitters that after many annoyances and interruptions from this unknown and perhaps unsuspected cause the assistance of an official inspector is required to remove the impediment.

Secondly. In addition to the dust impediment there is a process of wear and tear that destroys the particles of carbon which make contact with the platinum point at the end of the slender spring. If the instrument is delicately adjusted so as to respond to faint or distant sounds—which for the moment show off to the greatest advantage the beauty of the Blake invention—the destruction of the carbon particles is correspondingly more rapid. Hence, although the exclusion of dust lessens the evil, the natural action of the instrument produces a dirty ash, which causes similar annoyance and obstruction.

Thirdly. In consequence of the action just described, it is impossible to employ more than one battery cell where a louder voice or its transmission to long distances is required.

A remedy for this latter defect has been devised and patented by Mr. Moseley.

To remedy the first defect by the exclusion of dust the microphone action is enclosed in an air-tight box G (Fig. 1), the opening of which is closed by the diaphragm.

To remedy the second defect the carbon electrode A (Fig. 2) is made of a short cylindrical form, supported on the end of a stout brass wire spring, B, which is attached to a screw terminating in the milled head E.

The platinum electrode *c* is a small platinum head on the end of the light silver wire spring support D, ending in the milled head F.

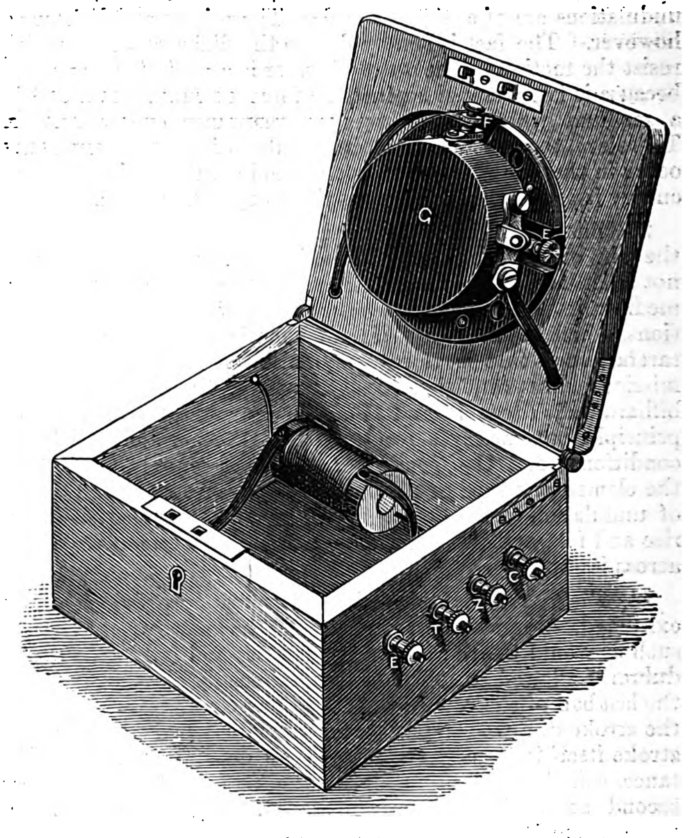

FIG. 1.—Moseley's Transmitter.

It will be seen, therefore, that when the transmitter produces any buzzing or confused sounds the terminals E and F may be instantly turned very slightly, which will at once present fresh material for the points of contact, and instead of keeping in order only one or two months, as alleged

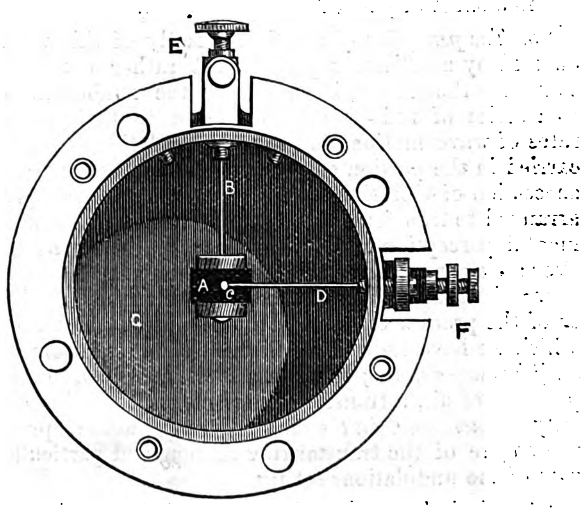

FIG. 2.—Moseley's Transmitter.

against the present instruments, there seems no reason why, with the improvements described, there should be any necessity for official attendance for ten or twenty years.

About seventeen years ago Mr. Moseley fitted up the Grand Hotel at Scarborough with nearly 400 electric bells and other apparatus.

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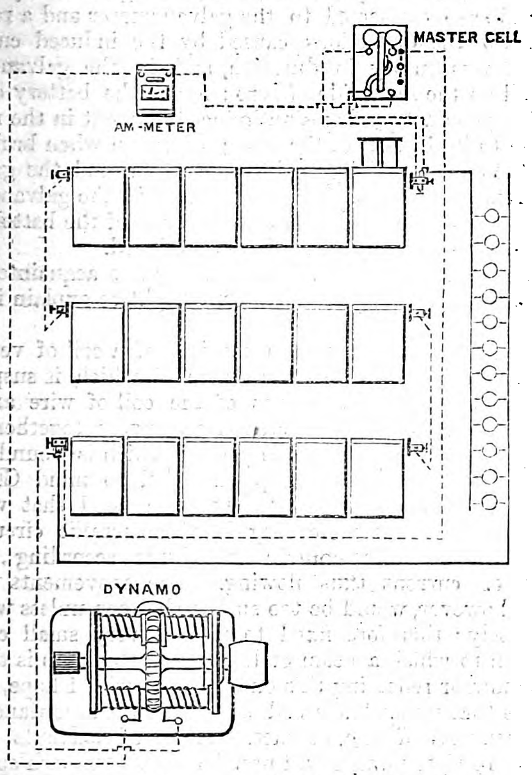
At that time he adopted various devices and precautions, which were, we believe, considered extreme and unnecessary; but we are not acquainted with such a large installation which has stood the test of time so successfully. This and many other important evidences of his conscientious foresight entitle any of his inventions to careful consideration.

As the invention above described is not patented in any other country than this, our readers abroad who are owners or licensees of the Blake transmitter patents are at liberty to adopt the ideas.

THE INSTALLATION AT COLCHESTER.

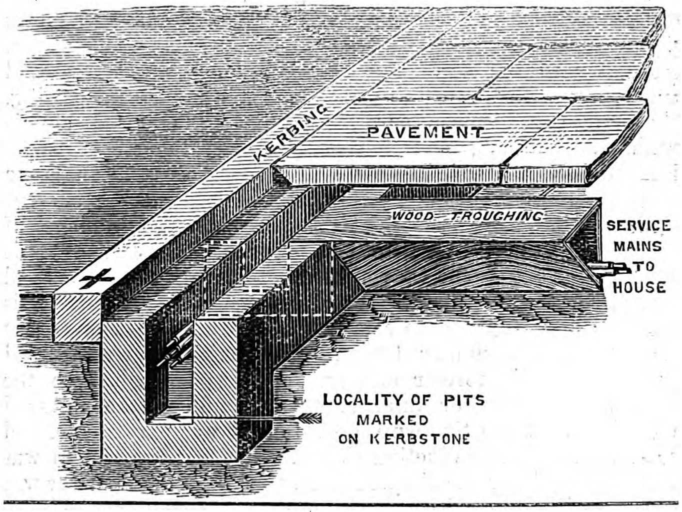
In the first portion of our report on the formal opening of this installation we referred to the meeting at the Town Hall and the reading of Mr. King's paper. At the conclusion of



Colchester Installation. Connections for charging the secondary batteries.

the paper the manager of the company, Mr. J. Offor, made a few remarks as to the estimated cost. Without entering into minute details, it is well known to electrical engineers that currents, where very great differences of potential exist, can be transmitted over comparatively small size wire. Mr. Offor pointed out that the system adopted at Colchester differed from the ordinary system used with incandescent lamps, inasmuch as the dynamos were high tension dynamos—Brush 40-lighters, in fact. The current generated by these dynamos was used to charge the secondary batteries in series, while the current was distributed from the secondary batteries in quantity. We must be somewhat emphatic in calling attention to this development of electric lighting industry, because such a strong opponent of secondary batteries as Mr. J. E. H. Gordon is compelled to admit that if secondary batteries can be made and so used they will be of great service. Now, at Colchester they are made and they are used. The charging mains from the dynamos, and the distributing mains from the lamps are placed in the same channels, easy of access, and so easy to inspect and test. We shall content ourselves just now, however, with describing the proceedings of the day, detailing the arrangements as we come to them. Mr. Offor went on to show that although the total cost of the batteries was roundly £4,000, and of the mains as used £1,500, there was a saving of from £2,000 to £3,000, for distributing the current to the 2,200 lamps would, with low tension current machines and lamps in multiple arc, have required mains that would have cost from £8,000 to £9,000. *The* one question in the minds and upon the tongues of many present was, what of the life of these batteries? If they have a fairly long life there can be no doubt as to the economy of such a system. This link in the chain can only be tested by time, and if we could venture to suggest a course to the company it would be that an exact history of these batteries be kept—that a rigid and continuous system of examination be maintained by men of repute unconnected with the company. It will pay the company to have these batteries watched with a keener watch than is kept upon the battlefield. After detailing the cost of plant, Mr. Offor referred to expenses and estimated receipts. The method of charging customers adopted at Colchester is ½d. per lamp per hour, and this is estimated to bring in a sufficient return to give a balance of between £1,000 and £2,000 on the right side, after paying all expenses and depreciating the plant.

A discussion was invited, and a number of questions were asked by the delegates from London, Brighton, Dudley, &c., present. The questions mostly related to expense and to



Colchester Installation. Street channelling with the mains.

length of life of plant. Our readers will have inferred that such questions could receive only general answers. Experience is absolutely necessary in order to obtain definite details as to lamps, batteries, &c.

At the end of the discussion the visitors went to the central station, and saw therein one of the battery rooms and the dynamo room. The paper of Mr. King has explained all this, but we may, perhaps, say that we understood that the Davey-Paxman (twenty horse-power nominal) engine had been constantly running for about two years without a hitch occurring at any time. The accompanying plan of the connection of the battery boxes will assist in explaining Mr. King's reference in the paper. The channels, a section of which is shown in the diagram, were opened for inspection—that is, a flagstone was raised, when it was seen that they were free from water, and there seems to be no doubt that the method adopted is satisfactory in this respect. All the charging and service mains we saw were lead-coated, upon the Berthaud-Borel system. One of the other battery stations was visited by many of the visitors, after which came luncheon. It is unnecessary for us to detail the speeches; they dealt with the special business of the day, the success of the lighting at Colchester, and generally with success to electric lighting. The company are certainly to be congratulated upon the arrangements at Colchester, and it is to be hoped that the future working will continue to prove that the somewhat sanguine estimate as to cost had not too roseate a hue.

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VOLTA AND MAGNETO ELECTRIC INDUCTION.*

BY WILLOUGHBY SMITH, M.R.I.

The subject which I shall bring before your notice this evening is "Volta Electric and Magneto Electric Induction," and I propose to describe some of my experiments in connection with this phenomenon in electricity and magnetism, which was discovered, named, and for forty years fostered, within this very building, by our universally esteemed and beloved Michael Faraday.

It is now thirty years ago that Faraday gave me my first lesson in volta-electric induction, at the same time impressing upon me the fact that physical science must ever be progressive and corrective, and that he was always pleased to learn that his experiments had been repeated by others with a view to their verification or correction. In the remembrace of this I have felt encouraged in coming before you this evening.

Doubtless all present are familiar with the fact that about 1819 Professor Œrsted made a discovery which has done much to advance our knowledge with regard to electricity and magnetism. This discovery arose from a very simple experiment, but it is none the less valuable on that account. I will now repeat this experiment, as the result obtained will lead up to and enable you to better understand what I may show later on.

Here is a length of copper wire, from the top surface and centre of which projects a metal pin, having balanced on its point a magnet. The position of the steel is, as you perceive, parallel with the wire, and that position being north and south, it will thus remain until, by pressing down this spring, the length of copper wire is placed in metallic circuit with this battery; and you observe that the steel needle immediately has a tendency to place itself at right angles to the copper wire, remaining thus displaced until the current ceases to flow, when the needle again obeys the influence of terrestrial magnetism and returns to its former position. This was Œrsted's experiment which led to the discovery that all bodies possess the qualities of a magnet whilst a current is passing through them. From this fact Faraday conceived the idea that, if a similar length of copper wire were placed parallel with the former one, and close to it, each time the circuit was made or unmade there would be an induced current flowing in this wire, providing it was part of a closed metallic or other conducting circuit. The first experiment was not successful, for the simple reason that the galvanometer was not sufficiently sensitive to be visibly affected by the very small current induced in so short a length of wire as that with which he made the experiment; nor was he prepared to find that induced currents were of such momentary duration. But failures with Faraday were merely stepping stones to success; he repeated the experiments with spirals of insulated wire instead of wires parallel to each other and in a straight line, thus getting comparatively long lengths in close proximity; by these means he gained the object of his search, the result of which he called "Volta Electric Induction."

Through the kindness of Dr. Tyndall I have here the identical spirals which were made and used by Faraday on that memorable occasion. One of these Faraday connected in circuit with a galvanometer, and placed it on the top of the other spiral, through which intermittent currents from a battery were sent at fixed intervals. On making the battery circuit he noticed that the needle of the galvanometer was deflected in one direction, and on breaking the circuit the needle was again deflected, but in the opposite direction. Faraday saw in his mind's eye each particle of the circuit through which the current was passing acting as a centre of force emitting its lines far from it, yet each of these lines returning to its own source; he in consequence made a series of experiments by placing various substances in the path of the lines of force to ascertain whether they would in any way be affected or intercepted by the substances so placed. For instance, he found that they were sensibly affected by iron, but with copper no satisfactory effects were perceived, although he felt sure that copper did in some way influence them, but so imperceptibly that he was unable to detect it. It was this conviction and the doubt by Faraday of the result of his experiment with regard to copper which led me to experiment in this direction. My apparatus and its arrangements being somewhat different to Faraday's, I will more fully describe them. Here are two flat spirals of fine silk-covered copper wire, about twelve inches in diameter, suspended, spider web fashion, in separate frames; the two ends of each spiral being attached to terminals at the base of its own frame. These two spirals, which are marked respectively A and B, will now be placed a definite distance apart, and comparatively slow reversals from a battery of ten cells sent through spiral A. You will see the amount of the current induced in B by observing the deflection on the scale of the mirror reflecting galvanometer which is in circuit with that spiral. These inductive effects vary inversely as the square of the distance between the two spirals when parallel to each other; the induced current in B being proportional to the number of reversals of the battery current passing through spiral A, and also to the strength of the current passing. Spiral A is so connected that reversed currents from a battery can be passed through it at any desired speed; B is so connected to the galvanometer and a reverser as to show the deflections caused by the induced currents, which are momentary in duration, and in the galvanometer circuit all on the same side of zero; for, as the battery current on making contact produces an induced current in the reverse direction to itself, but in the same direction when broken, of course the one would neutralise the other, and the galvanometer remain unaffected. To obviate this, the galvanometer connections are reversed with each reversal of the battery current, and thus a steady deflection is produced.

Perhaps, for the information of those not acquainted with the construction of a galvanometer, I ought to explain it more fully.

The one I am about to use consists of a coil of very fine silk-covered copper wire, in the centre of which is suspended a very small magnet; the ends of the coil of wire and the ends of spiral B are connected respectively together, thus forming a metallic circuit, one part of which is wound into a coil and the other into this spiral. Call to mind Œrsted's experiment, and it will be readily understood that when a current of electricity is flowing in this metallic circuit the magnet will be influenced in magnitude according to the amount of current thus flowing. The movements of the magnet, however, would be too small to be seen unless watched very closely; therefore fixed to it is a very small concave mirror, on to which a beam of light from the lamp is thrown, and the mirror reflecting this on the scale will, I hope, enable all to see that somewhat broad beam move in accordance with the movements of the magnet. Reversed currents at the speed of 100 per minute will now be passed through spiral A, and you will observe that the induced currents in B give about 28 divisions on the scale of the galvanometer; we will note this on the black board. Now we place this plate of iron midway between the two spirals, and you observe the deflection on the scale is reduced to about one half, or in round numbers 15, showing clearly that the presence of the iron plate is in some way influencing the previous effects. We now remove the iron, when you see the deflection returns to its original amount, 28, and if I replace it by a similar sheet of copper the interposition does not alter the deflection. The results of this experiment are therefore as follows, viz:—

Speed	100 reversals per minute.
Induced current	28° deflection.
Iron interposed	15° "
Copper do.	28° "

I may here state that, up to this point, the results of my experiments confirm those of Faraday, that all dielectrics and diamagnetic metals appear in no way to interrupt or interfere with the lines of force.

Now let us repeat this experiment with the speed of the reversals increased ten times, or to 1,000 per minute; the spirals are in the same position as before, and the deflection is now about 86. I have already said that the current is in direct proportion to the speed of the reversals;

* Lecture delivered at the Royal Institution, June 6, 1884.

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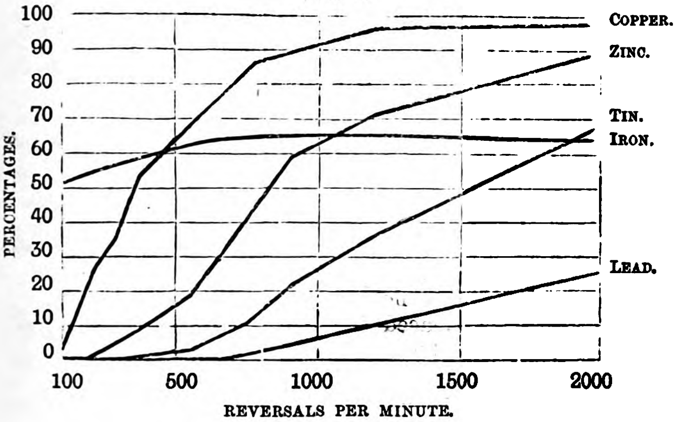
the battery and spirals remaining the same. It might therefore cause confusion were I not to explain that the deflection would be ten times as great as it was with the lower speed of reversals, but that the scale of the galvanometer not being sufficiently long to record this high deflection, we have what is termed "shunted" a part of the current; that is to say, between the two ends of the galvanometer coil we have inserted a length of copper wire, so that the current on arriving at one terminal of the coil divides, part going through the coil of the galvanometer, and the rest through the shunt; the two currents reunite at the other terminal of the galvanometer. By varying the resistance of the shunt, therefore, the desired amount of current can be sent through the galvanometer. In this case sufficient current passes to keep the beam of light just on the scale at about 86 divisions. We now interpose the sheet of iron as before, and you see the deflection falls again to about one half. We withdraw the iron and the deflection returns to its former amount, 86. We now interpose the copper, when the deflection, instead of remaining stationary, as in the former experiment, actually falls to 17. We now obtain the following results, viz. :—

Speed	1,000 reversals per minute.
Induced current...	86° deflections.
Iron interposed ...	40° „
Copper	17° „

Now the question arose, why does copper, at the low speed of the reversals, apparently have no effect, while at the higher speed it plays so important a part in intercepting the lines of

Fig. 1.



force? The only solution of the phenomenon which suggested itself to me was, that the lines of force have first to polarise the molecules of substances placed in their path before they can pass through them, and in this process time is a very important element to be considered. For instance, at the slow speed there is sufficient time between the reversals for the copper to polarise before the next reversal takes place; whereas at the high speed the copper plate is unable to fully polarise before the next reversal arrives, and then the two induced effects partly blend, and being opposite in direction tend to cancel each other. Now, if this really be the case, the higher the speed the less should be the proportional deflection when experimenting with copper. The time at our disposal this evening will not allow of accurate measurements, or of other substances being experimented upon, but careful and reliable measurements have been made, the results of which are shown (Fig. 1).

It will be seen by reference to these results that the percentage of inductive energy intercepted does not increase for different speeds of the reverser in the same rate with different metals, the increase with iron being very slight, whilst with copper the induced current set up is so long in duration that when the speed of the reverser is at all rapid, the current not having time to exhaust itself before the galvanometer is reversed, tends to produce a lower deflection. If the speed of the reverser is further increased, the induced current is received on the opposite terminal of the galvanometer, and thus a negative result is obtained.

My next object was to verify, if possible, by a different system of experiment, the correctness of this theory, and I could think of no better arrangements than those used by Faraday in some of his experiments on magneto-electric induction. I was not, however, encouraged to proceed in that direction; for, if my theory were correct, the results published by Faraday could not be so, and knowing what a careful experimenter he was I could not doubt but that he was right. After long and careful thought on the subject, I ventured, however, to repeat some of his experiments, and I will again repeat them before you presently.

About sixty years ago Arago made the discovery in electrical science that if a plate of copper be revolved close to a magnetic needle, or magnet suspended in such a way that the latter may rotate in a plane parallel to the former, the magnet tends to follow the motion of the plate; or, if the magnet be revolved, the plate tends to follow its motion. This simple apparatus will better illustrate the experiment. Here is a copper plate one-tenth of an inch thick and 7½in. in diameter, fixed to a vertical spindle, and enclosed in a wooden case having a glass cover; beneath the copper plate is a small grooved pulley, around which passes an endless band, the band also passing round this horizontal wheel, to which a handle is fixed, so that it may be conveniently revolved. A small brass disc is here provided, in the centre of which is fixed a pointed steel pin, and on this pin is balanced a steel magnet. I will place this on the glass cover over the centre of the copper plate. Now, if the copper plate be made to revolve, you will see that the magnet will revolve also, in the direction of the copper disc. There it goes! No doubt you observed how sluggish its movements were at first, and that it was some time before it followed the movement of the disc. This was owing to the attraction of the earth's magnetism on the magnet, which held it in bondage until the speed of the disc was sufficient to overcome its attraction; then, once released, how merrily it appeared to obey the influence of a superior power. The disc now being at rest, the needle has returned into bondage; but if I judiciously use the influence of this magnet to partially neutralise the influence of the earth's attraction, you will observe how much more quickly it obeys the influence of the mysterious power of the revolving disc. There it goes! Apparently more merrily than before. Were I lecturing on moral philosophy, I certainly should make use of the similes which might be drawn with advantage from experiments with this simple instrument. But my subject being of a different nature, I will resume without further digression.

If the order were reversed and the magnet removed, the copper disc would act in the same way as the magnet has just done. This is the phenomenon discovered by Arago, who also asserted that the effect takes place, not only with all metals, but with all substances. On this latter point there has always been a difference of opinion between experimenters who have endeavoured to verify Arago's statement. As far as my experiments have gone, I have only obtained reliable results from good conductors of electricity; but I believe that, theoretically, Arago is right, for as all substances are, in a certain degree, conductors of electricity, it I think necessarily follows that we only want sufficiently sensitive instruments to develop the phenomenon, as Arago asserts, in every substance. It has been stated that all substances when subjected to a sufficiently strong magnetic force are found to give indications of polarity, and also, when magnetic force acts on any medium, whether magnetic, diamagnetic, or neutral, it produces within it a phenomenon called magneto-induction. If this be the case, it materially strengthens the correctness of Arago's assertion.

Arago's discovery that copper, a non-magnetic metal, was influenced by a rotating magnet, or that a magnet was in the same way affected by a rotating disc of copper, was looked upon at the time as a new and remarkable phenomenon in induced magnetism by philosophers both in England and other countries; but it was Faraday who, by the assistance of his knowledge of the evolution of electricity from magnetism, gave the true solution by proving it to be the effects of

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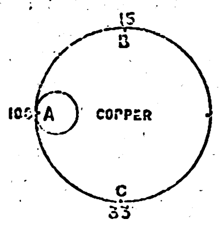
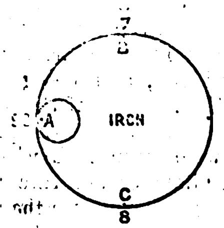
electrical currents induced in the disc on account of its motion in a magnetic field. He not only proved by simple experiments the correct interpretation of the phenomenon, but he saw the way to making the discovery of Arago a new source of electricity, not despairing by the aid of his knowledge of terrestrial magneto-induction of being able to construct a new magneto-electric machine. For this purpose he arranged an apparatus, similar to the one I have here, which is simply a permanent magnet so fixed that discs of metal or other substances can be rotated between its poles. Two wires leading one from each terminal of a galvanometer were applied to any desired part of the revolving disc, and the deflections on the galvanometer noted. The first experiments were made with a very large compound permanent magnet, and with what would now be termed a quantity astatic galvanometer. His discs of metal were 12in. in diameter, and about one-fifth of an inch in thickness, fixed upon a brass axis. He experienced difficulty in making contact between the terminals of the galvanometer and the edge and other parts of the revolving disc, as also in maintaining uniform velocity of rotation. With a much smaller magnet and a more sensitive galvanometer the results were more striking. Thus, with his accustomed simplicity, he demonstrated the production of a permanent current of electricity from an ordinary magnet, at the same time asserting that with powerful magnets and rapid rotation of a copper disc very strong currents would be produced. What a wonderful lesson this apparently simple machine teaches, for it is able to exert the power that has its origin within itself on external matter without in any way exhausting or diminishing that power!

The apparatus that I employed for my experiments is the same that I shall use this evening. On this stand is fixed an electro-magnet, the poles of which are so placed that the rim of the disc under experiment can be freely revolved between them. The cores of the electro-magnet are 1·75 inch in diameter, and are wound with twelve layers of silk-covered copper wire of high conductivity, ·028 of an inch in diameter, each layer having sixty-one turns; each core has 732 turns, making a total of 1,464 turns on the two poles. The total resistance of the wire is 13·75 ohms, and through this flows the current from twelve Leclanché cells. The same galvanometer is used as with the other experiments, being brought in circuit with the disc by means of the axis on which the disc revolves, and a metal brush which forms a rubbing contact on the rim of the disc. This, working on a fixed centre, can be readily shifted to any part of the circumference of the revolving disc. The disc is revolved by this cone-shaped pulley, worked lathe fashion, connected by an endless band to a small grooved pulley fixed on the same axis as the metal disc. We will now make a few experiments with the copper disc, which is now revolving at the speed of one thousand revolutions per minute, and the connections are so made that the current will be taken from the rim of the disc just as it passes between the poles of the magnet. On pressing this spring the circuit is complete, and you observe the effect of the current on the scale of the galvanometer; it is about 100 divisions. We will now remove the contact to about one fourth of the diameter of the disc or top position, so that the current will be taken at that distance from the poles of the magnet as the disc is approaching the poles; now, on completing the circuit, you observe the deflection is reduced to about fifteen divisions. The contact will now be removed to the opposite side, or bottom position of the disc, so that the current will be taken at the same distance from the poles, but after that part of the disc has just passed between them; on completing the circuit you see the deflection has increased to thirty-three divisions. Let us note these results as follows:—



We will now replace the copper disc with one of iron, and repeat precisely the same experiment. We find that the current from position A is so great that it is necessary to insert a resistance of 500 ohms in the circuit to bring the beam of light on to the galvanometer scale; as before shown, by means of inserted resistance we can obtain any desired deflection. It is now about 98 divisions, and that we will take as the right measure for position A. We take B or top side position, and you observe that the deflection is only 7 divisions; the connection is now placed at position C or bottom side, and we get but very little more current, as the deflection is only increased by one division. The results with iron may therefore be noted as follows:—



500 ohms in circuit.

If we compare the results of these experiments with those obtained with the same metals in volta-electric induction, we see that iron remains fairly uniform in its results in both cases, but that copper behaves differently. You must not, please, take the figures given as being absolutely correct, the experiments having been somewhat hurriedly made, and merely given with the view of enabling you to understand the results of carefully made experiments with various metals. These results are graphically shown in Fig. 2.

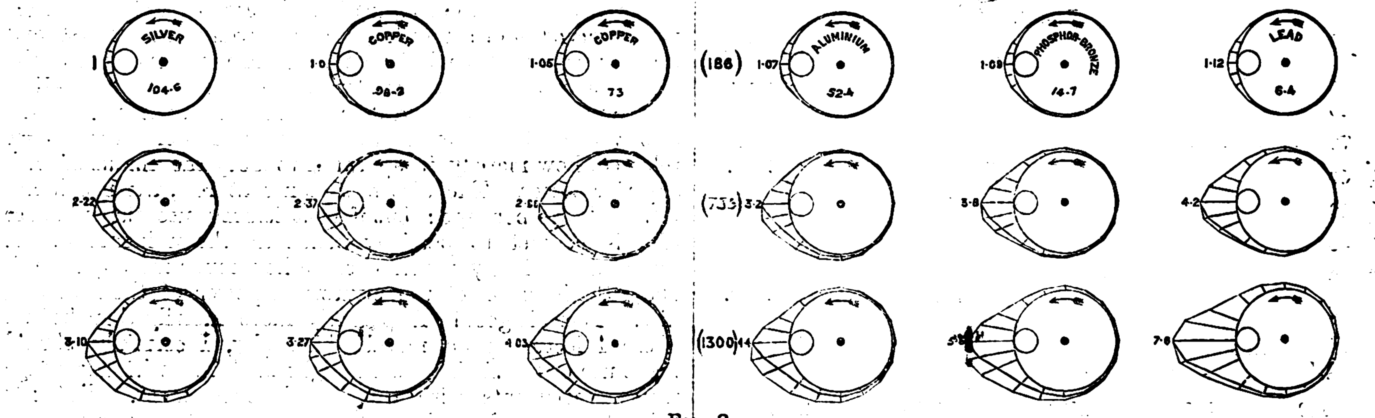


Fig. 2.

and, as the measurements are to scale, they can be directly compared with each other. The large circles represent the revolving discs, the small ones show the position of the poles

of the electro-magnet, and the arrows the direction of rotation. The boundary lines show the electromotive force at every point round the revolving disc; thus in every case the strongest point is, as might be expected, directly in front of the poles of the exciting magnet, the strength gradually fading from thence on either side. The blue portions show the excess of inductive effect there produced, relatively to a point equidistant from the magnetic poles, but on the other side. If the current set up in the metal simply depended upon the intensity of that part of the magnetic field through which the metal was passing, then equidistant points on either side of the magnetic poles should produce equal deflections, because the magnetic intensity is equal; on inspecting the diagrams, however, it appears as if a very sluggish inductive effect were produced in the diamagnetic metals of high conductivity, the sluggishness increasing with the conductivity of the metal, as though the atoms took a comparatively long time to accommodate themselves to the changes in the magnetic field through which they were passing. This, I think, confirms the theory I have ventured to advance with respect to copper while under the influence of induction.

is but very little of what I have termed "drag" in those metals. The consequence of this is that with iron the amount of current is nearly in direct proportion to the speed of the disc, whereas with copper the increase is very small, the current produced by the two metals being as 1 to 7, at a speed of about 1,300 revolutions per minute. The higher the specific conductivity of the diamagnetic metal the greater the "drag," and consequently the less the current at the poles, this being more manifest at the high speeds, which does not, however, agree with the results obtained by Faraday, for he found that the currents were proportionate in strength to the conducting power of the bodies experimented with; or, in other words, that the higher the conductivity the greater the current; whereas I find the reverse to be the case, as shown on the diagram before you.

Faraday also obtained much better results from copper than from iron, and thus he recommended copper for his new magneto-electric machine. Here, again, my results do not agree with his, for I find that iron gives much better results than copper, as shown on the diagram, and also that iron has the great advantage that the current increases almost in direct

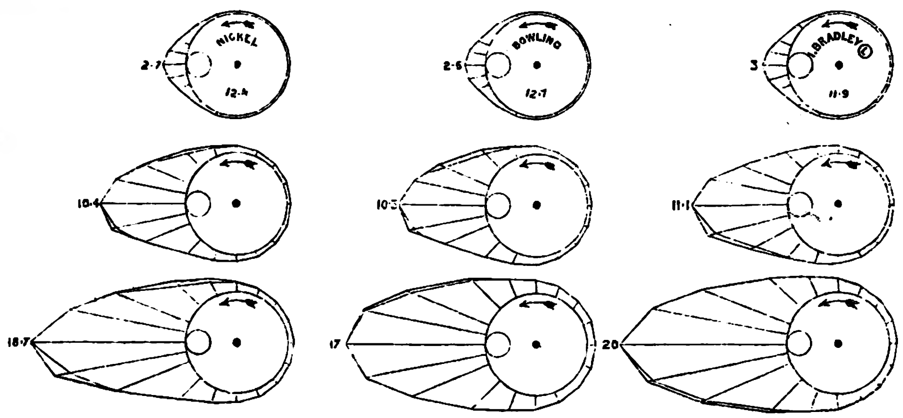


Fig. 3.

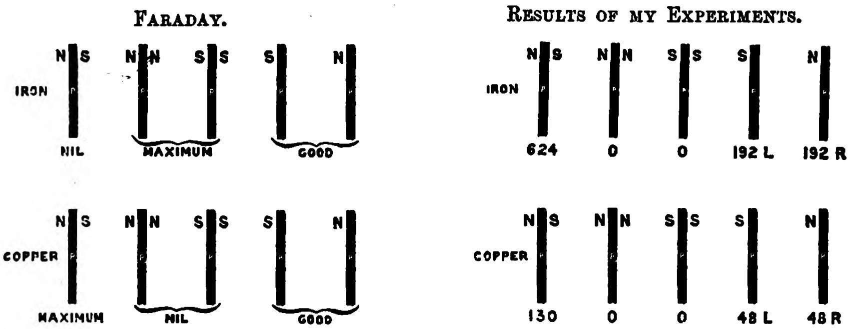


Fig. 4.

If, as in the case of volta-electric induction, the lines of force are generated too quickly, or, as in the case of magneto-electric induction, the diamagnetic body passes too quickly through the magnetic field, the atoms of the substance in each case have not time to polarise with sufficient rapidity to radiate in the same time or place as when influenced more slowly by this force. This would account for the apparent interruption of the lines of force by the copper plate in the volta-electric experiments, and also for the "drag" or retardation on the disc of the same metal as shown by the blue colour in the diagram whilst part of it is passing quickly through a magnetic field. That being the case, it is easy to perceive that a speed of the copper disc might be attained, when the current would be *nil*, through the atoms being unable to polarise in the allotted time. Not so with magnetic metals as iron or nickel, in each of which the atoms appear to be very susceptible to magnetic influences, and to polarise very quickly, as shown by the way in which part of the disc is affected just before entering between the poles, as shown in the blue colour in the diagram (Fig. 3).

The atoms must as quickly depolarise, as you perceive there

proportion to the speed, whereas copper does not; in fact, as already stated, a speed might be obtained at which copper would give *no* current.

Faraday in summing up the results of his experiments on Arago's phenomenon says, "Nothing can be more clear, therefore, than that with iron and bodies admitting of ordinary magnetic induction opposite poles on opposite sides of the edge of the plate neutralise each other's effects, while similar poles exalt the action. But with copper and substances not sensible to ordinary magnetic impressions *similar* poles on opposite sides of the plate neutralise each other, and opposite poles exalt the action." Perhaps you will more readily grasp the subject by reference to the diagram (Fig. 4), in which P represents the plates of metal, and the other letters the respective poles of the magnet and their position. Here again it will be seen that the results obtained by me are opposed to those given by Faraday. I have given the actual figures obtained in my experiments, and it will be seen that the only difference between the metals copper and iron is that iron gives the higher current of the two, as it has done in all my experiments.

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I have no doubt but that we should be able to get approximately near for all practical purposes to the relative conductivity of metal by revolving discs of the metal under test in a magnetic field, and measuring the mount of current between the poles or the amount of "drag." The results given (Fig. 5) show how suitable the method also is for obtaining the saturation point of the cores of electro magnets, whether of different qualities of iron or other magnetic metals.

Very recently an Electrical Congress held in Paris agreed to a universal system of electrical units. I believe the value of some of the units to be adopted was determined by passing masses of metal at varying velocity through a magnetic field of uniform intensity and noting the amount of current so produced. I understand that the results obtained by different experimenters did not agree, and from what I have shown you this evening you will readily understand the reason of the discrepancy. To obtain accurate results the influence of what I have called "drag" must certainly be taken into the calculations as an important factor.

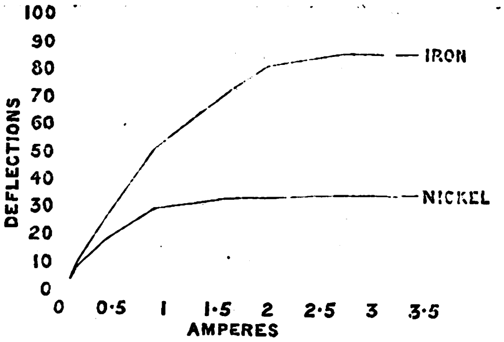

Fig. 5.

There are other matters to which I attach importance connected with the experiments I have endeavoured to make clear to you, especially with those on magneto-electric induction, which I publish for the first time this evening; but of the many good rules of this Institution there is one which does not allow me to tax your patience for more than one hour, and as I have already exhausted that time I must not detain you longer except to thank you, which I do most sincerely, for the kind attention you have given to my humble endeavours to advance our knowledge of "Volta-Electric and Magneto-Electric Induction."

LEGAL.

The Board of Works for the Wandsworth District v. the United Telephone Company (Limited).

This case came before the Master of the Rolls and Lords Justices Bowen and Fry, in the Court of Appeal, on the 12th and 13th inst. Mr. Webster, Q.C., Mr. Cozens-Hardy, Q.C., and Mr. Moulton were for the appellants; Mr. Philbrick, Q.C., Mr. T. L. Wilkinson, and Mr. Lane were for the respondents. It was an action by the Wandsworth Board of Works against the United Telephone Company for erecting telephone wires over the highways of that district, and the complaint was that the company had without the consent of the Board placed wires over, along, and across certain of the streets and highways for the purpose of telegraphic or telephonic communication, the same being alleged to be dangerous to persons using the streets, and the Board claimed an injunction against placing any wires over streets under their control without their consent. The company denied that the wires were dangerous to the public, and that was the real issue in the case. This was the first case which had come before the courts to raise the question whether a telephone company has a right against the will of the local authority to place wires across the streets. The case was tried on the 8th of May, before Mr. Justice Stephen without a jury, and the learned judge gave his decision against the company. The case for the Board was put on three grounds—first, they contended that the company were subject to the provisions of the Telegraph Act of 1863, and were as such forbidden to place a telegraph over or along or across a street or public road, except with the consent of the body having a control of it; secondly, that the Board, as owners of the soil, had an absolute right to prevent the company from suspending wires over their road, upon the principle that the air above the road was as much theirs as the road itself; and, thirdly, that the overhead wires were in fact dangerous to persons using the road, and therefore a nuisance. Upon the first point the argument was that, as it had been held in the Attorney-General *v.* the Edison Telephone Company that a telephonic message is a telegram, therefore the Telephone Company is a telegraph company within the Act of 1869, and therefore a company under the Act of 1863 and so within the 12th section of that Act. But the learned judge held that as the company were only licensed by the Postmaster-General to carry on the telephone business, from which otherwise they would be restrained by the Act of 1869, and had none of the powers of a company under the Act of 1863, therefore the argument for the Board on this first point failed. Then as to the second point, the learned judge referred to the case of Coverdale *v.* Charlton, which went to the Court of Appeal, and was recognised in a case of St. George's, Southwark, in the Rolls, in which it was held that the rights of the local authority extended not only to the surface of the highway, but to a reasonable depth below it—that is, to such an extent as necessary to its safety and stability, and he said, "It seems to me that the present case must be decided upon the principle there laid down. The case does not directly decide anything as to the extent of a street upwards; it only limits its extent downwards. It does it, however, upon grounds which seem to me to apply equally in each direction. If it can be shown that the management and care of the street require some degree of control over the air immediately above it, as well as over the ground immediately below it, it seems to follow that the vesting of the street itself in the District Board must involve property in part of the air above the surface of the street as well as property in part of the ground below it. Now, it is self-evident that in many cases the air immediately above the street may be dealt with in such a manner as to affect the safety and comfort of the street, as, for instance, if an electric wire passes across the street at such a height as to interfere with the traffic. Such a case might be dealt with as a nuisance at common law, but might it not, apart from the law of nuisance, be treated as a trespass to the property of the Board? So long as the wire is at a height which actually interferes with the traffic the question is of no practical importance, but when it is suspended at such a height and in such a manner that it does not interfere with the traffic of the street, except possibly in some extraordinary case, the question becomes one of great importance;" and in order to illustrate this the learned judge went on to give his opinion as to the third ground on which the Board based their claim. "This ground," he said, "is that the overhead wire is a nuisance to the highway, and that as such they are entitled to have it removed, apart from the question of property. This it was agreed was a pure question of fact. The evidence given on both sides appeared to me to show that the wire in question is nearly new, and that it was properly taken care of and had been lately examined and found to be in perfect condition, and likely to last for many, or, at all events, for several years, without becoming perceptibly weaker than it now is. It causes, and in the common course of things is likely to cause, no perceptible danger to the public, though it is no doubt possible that a violent storm might blow it down, just as it might blow down the chimneys to which it is in most places attached. There was, however, evidence that on two occasions wires of a similar character had, in violent storms, been blown down in such a manner as to become a source of some danger to persons or carriages passing along the highway. Upon the whole, though I cannot say that absolutely no danger arises from the position of the wire, I do not think that apart from the question of trespass it would form an indictable nuisance." That being so, the learned judge went on to say that in his view the question upon which the case must turn was whether the street vested in the Board extended to such a height above the ground that the suspension of the wire over it was a trespass which entitled them to an injunction. He was, he said, first of opinion that it was not so, but had come to the conclusion that it was. "Upon the best consideration," he said, "it seemed to him that Parliament intended to give to the District Board proprietary rights over the street, including in that a certain space upwards as well as downwards, in order that the Board might form a judgment as to the expediency on public grounds of permitting or refusing to permit various acts which, without being actual nuisances in such a sense as to be indictable, might, nevertheless, be regarded as undesirable innovations. (He put the case of a bridge connecting two houses on different sides of the street.) So with regard to telegraph or telephone wires, a single wire might be no nuisance, yet if no one had a definite right in the interest of the public to object to its erection such wires might be multiplied to any extent, and might collectively constitute a very appreciable nuisance." "I do not," said the learned judge, "suppose that the Legislature thought of this when the streets were vested in the District Boards, yet I think that the object of the enactment was to vest the Boards with the character of owners, in order that they might use for the public convenience rights which a prudent private owner would use in his own interest and in the interests of his tenants; and I am much strengthened in this view by the provisions of the Telegraph Act of 1863, for if private persons had at common law a right to suspend wires over the streets, subject only to the general law of nuisance, I do not see why the Legislature should in express words have authorised telegraph companies to do so, or why they should have required them to obtain the consent of the public body having control of the street. If they already possessed the power at common law there was no need to give it, though it might be necessary to qualify it." For these reasons the learned judge gave judgment in favour of the Board, though as he did not think the wire caused at present any appreciable danger to the public, and there was certain to be an appeal, he delayed granting the injunction. The company now appealed from that decision.

Mr. Webster, Q.C. (with Mr. Cozens-Hardy, Q.C., and Mr. Moulton) appeared on behalf of the company, and argued in support of the appeal. There were, he said, no posts in the street, and the wires were fixed up

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overhead, 30ft. above the street, at such a height, as was admitted, as not to interfere with the traffic in the street, even in the case of a fire escape. [Lord Justice Fry: Any existing fire escape; future ones might be higher.] The more recent fire escapes are lower than the former ones. [Lord Justice Fry: The learned judge decided not upon the ground of nuisance, but upon the ground of a proprietary right in the column of air over the highways?] Yes. [Lord Justice Bowen: It may be that we may have to decide an intermediate point, not that the Board are absolute owners of the column of air over the street, but that they are so far the owners, or are the owners to such an extent as may be necessary to secure the safety of the passengers or prevent danger to them.] That is not denied; but it is submitted that the point does not here practically arise, because there was nothing in the wires to cause nuisance or danger to the public. [Lord Justice Bowen: The Board have the soil vested in them to such a depth beneath the street as necessary to protect the safety of the road, and so they may have a similar right in the air over the street.] That is not disputed; but it is submitted that the wires here cause no danger to the public. [Lord Justice Fry: But it appeared that there was a possible danger from which the public ought to be protected.] That might be sufficient, and it is admitted that the Board are so far owners as to be entitled to protect the public from danger at any height above the streets, and would have sufficient powers to protect all street traffic, and prevent anything which if it were to occur would be a nuisance or a danger to the public. This is freely admitted, but it is submitted that the question here does not arise, as there is no possible reasonable apprehension of danger to the public from the use of these wires at such a height overhead. As to the doctrine *cujus est solum ejus est usque ad cœlum*, that whoever is the owner of the soil is the owner of the air over it up to the heavens, that legal maxim has no application here, because the Board are not absolute owners of the soil and have no rights either over or under the ground, except so far as necessary for the safety and the interests of the public. [The Master of the Rolls: They do not claim to be absolute owners.] No; if they had alleged it it would have been denied and disproved. They have only such rights as pertain to them as guardians of the highways. The wires are so high overhead, being fixed to the houses, never less than 30ft. above the streets, as to cause no danger to the public. [Lord Justice Bowen: That is a question of fact.] It is so, and it was virtually decided by the learned judge in favour of the company. [The Master of the Rolls: The others are questions of law.] They are so, and they are to be argued, and he proceeded to argue them accordingly, reading the judgment and commenting upon it, and reading the passages as to the right of the Board to the soil beneath the street so far as necessary for the safety of the highway. [Lord Justice Fry asked whether he would admit that this would entitle them to prevent excavations at any depth which would endanger the highway?] No. [Lord Justice Fry: Why not? Is there not a right to the extent necessary to protect the highway?] The soil beneath the street is not absolutely vested in the Board, but only the street, and the Board have only a right to protect it. [Lord Justice Fry: The Metropolitan Local Management Act vests the streets in the Boards.] Not the soil, only the street and the pavements and materials of the roadways; it does not mean any right of ownership in the soil. The Act expressly enumerates pavements, stones, &c. [Lord Justice Bowen: That merely does not convey the soil.] It surely rather excludes it. [Lord Justice Fry: No, for it means loose stones, &c.] And that is all it is intended to vest in the Board. That being so they have no right of property in the soil, and have only a power to protect the highway from actual danger. Here there is no such danger, and so they have no right to interfere. [The Master of the Rolls: The Act does more than give the Boards powers of control, it vests the streets and highways in the Boards, that is to the depth ordinarily necessary for the safety of the highways.] It is submitted that it is not so, and that the soil of the street is not vested in the Boards. The Boards had only power to prevent danger to the public, and here the learned judge himself had found that there was no danger. Yet in his judgment he had very much mixed up the right of property with the power to prevent danger. [Lord Justice Bowen: If there is a right of property in the air over the street it is not material whether there is a danger it is desirable to prevent.] Yet the learned judge rather mixes them up in the end of his judgment. [Lord Justice Fry: He a little departs from the ground of property, no doubt, but is there not a basis of good sense in the argument in favour of some power in the public body to prevent danger?] No doubt, where any danger arises, but here there is none. [The Master of the Rolls: The learned judge puts the case of a bridge over a street, but a bridge over a highway, as the Rialto at Venice over the canal, may endure for ages; only the learned judge says if one man is allowed to put a bridge between two houses then some one else may make another, and so turn a street into a covered way or tunnel.] Here, however, in the conclusion of his judgment, the learned judge declared that there was no "appreciable actual danger" in the wires, and so it is clear that his judgment, at least on his reasoning, can only be supported on the ground of property in the air overhead, and that, it is submitted, is not sustainable. [Lord Justice Bowen: Is there not a proprietary interest in the Board so far as necessary for the public welfare?] That need not be disputed. [Lord Justice Fry: If so, does it not conclude this case?] No, for there is no present actual danger. [Lord Justice Fry: But if there is such a proprietary interest, surely it would extend not only to such wires as cause actual present danger but also to such possible dangers as may be apprehended?] It is not admitted to that extent; nor did the cases cited go to that extent.

Mr. Cozens-Hardy, Q.C., followed on the same side, entering into the authorities, and arguing that they had not gone to the extent of vesting in the Boards any property in the soil under the streets. With reference to the theory of the right of an owner of land to a column of air over it there was much curious discussion, and as a test the case of a balloon was put, whether its going in the air over a man's land was a trespass, and conflicting *dicta* were cited about it.

Mr. Wilkinson (with Mr. Philbrick, Q.C., and Mr. Lane) appeared for the Board, and argued in support of the judgment, contending that they had a right in the soil of the street and the air over it, which was infringed by the fixing up of the telephone wires.

The case was here adjourned to the following day, the 13th inst., when their lordships gave judgment, allowing the appeal.

Judgment.

The Master of the Rolls said that the solution of the question depended upon the construction of the Act of Parliament which gave powers to the Local Board. Whatever those powers might be, there could be no doubt that if it had been shown that the wire was a nuisance and interfered with the proper uses of the street as a street, then the plaintiffs would be entitled to an injunction, whether the wire was within the street or not. But the learned judge had found that there was no appreciable danger from the wire. It could not be said that the wire interfered with the traffic of the street, the word "street" being used in its ordinary acceptation as to the width between houses; and therefore there was no ground on which the claim for an injunction could be maintained, unless the mere fact of putting up the wire was a trespass upon the property of the Local Board. His lordship understood the learned judge to have decided upon the ground that there was such a trespass, and that the plaintiffs were entitled to an injunction whether they were injured or not. The Local Board had no rights except under the Metropolis Management Act, 1855. That Act had been considered in Rolls *v.* the Vestry of St. George the Martyr, Southwark, ("Law Reports," 14 Ch. D., p. 785). The Act says that all "streets" shall "vest in and be under the management and control of the District Board." The same question arose in that case as in the one in question as to the meaning of the words "vest" and "street." The meaning of these words had been considered by the Court of Appeal in the case of Coverdale *v.* Charlton. His lordship's view in that case was that the word "vest" passed the property in whatever was the subject matter to be dealt with, so as to enable any one other than the public was concerned, *i.e.*, without infringing their duty to keep the street as a street. It was not necessary in that case to decide as to the duration of the right, but in a subsequent case the Court of Appeal decided that the right only existed as long as the thing was a street. Agreeing absolutely with that, it seemed to his lordship that his opinion in the case of Coverdale *v.* Charlton was that property in a street passed to the Local Board, and that if the thing ceases to be a street the property ceased also. The question then arose in that case as to the meaning of the word "street." It was suggested that the word only meant a right of way, or the mere surface. But the Court went further than that, and held that the street went below the real surface. In his lordship's opinion that was the basis of the judgment. The judgment of Lord Bramwell seemed to show that with regard to depth, the property passed in what Lord Justice Fry had called "the area of ordinary user," that is such user as is needed for the ordinary works done in a street. The judgments of Lord Justice Cotton and himself did not differ, and the groundwork of the judgment of the Court, as to depth at all events, was that in the statute in question, in which the word "street" is used, and the word "land" was not used, you must give to the word "street" the meaning popular at the date of the Act, and that as regarded depth, "street" meant that which contains the area of ordinary user existing at the date of the Act. That judgment gave the principle to be applied in the present case, where it was to be applied to something above the surface. He was not going to question that which had been laid down by Lord Coke, that when a man has conveyed "land" in terms, every right is passed which is covered by that land down to the centre of the earth, and *usque ad cœlum*. That was by the common law of England. But it does not follow that the same would be conveyed where the grant is by the word "street." Supposing it did, yet the question was as to what was the meaning in the statute in question, which dealt with "streets," of which the public had the use, and with people who, for the benefit of the public, had the property in and the guardianship of these streets. It seemed to his lordship logically to follow that those who came to the conclusion that in this statute the word "street" included that which below the surface is within the ordinary area of user of the street, must also hold that the same rule applies to that which is above the surface, and that it includes that area of air which is the area of ordinary user of the street as a street. His lordship doubted very much whether the height was confined to the present height of a fire escape, and he would not give a measure of height. Applying that rule to the wires in question, it could not be said that to walk along the tops of the chimneys to which the wires were affixed was an ordinary user of the street as a street. The statute did not pass property over the street, but only in the street. Therefore, no property passed in that part of the air in which the wires were placed, which, in ordinary language, were wires placed over and not in a street. Mr. Justice Stephen had construed the word "street" too largely, and could not grant an injunction on the mere ground that there was a trespass. As to the argument that the wire could not be put up without the leave of the Board, it was an endeavour to apply the interpretation of a particular phrase in a statute to a different phrase in another statute which was incorporated with the first. His lordship was of opinion that the case was within the principle laid down in Coverdale *v.* Charlton, and that the wires were not placed upon property of the plaintiffs so as to enable an injunction to be granted on the ground of trespass.

Lord Justice Bowen gave judgment to the same effect.

Lord Justice Fry said that Mr. Justice Stephen, although he had proceeded upon right lines, had erred in applying the case of Coverdale *v.* Charlton, and intending to follow the case, extended the area vested in the Board so as to make it include the area of possible interference.

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COMPANIES' MEETINGS.

The Faure Electric Accumulator Company (Limited).

An extraordinary general meeting of the shareholders of the above Company was held at the City Terminus Hotel, Cannon-street, on Thursday last, Mr. Harcourt-Turner in the chair.

The SECRETARY having read the notice calling the meeting,

The CHAIRMAN said that before proceeding to the business calling the shareholders together they would naturally expect to hear something from the Committee of Inquiry as to what they had done since the last meeting. First and foremost, he had to tell the meeting that they had changed the solicitors of the Company. They took that step because it was felt that as the inquiry went on questions might be raised as to the validity of some of the contracts, of which there had been many, that had been entered into, and that it might be necessary to take steps against M. Philippart; and a respectable firm like Messrs. Campbell and Co., who had drawn up those contracts, and who represented M. Philippart as well, could not be asked to blow hot and cold with the same breath. It was therefore thought better for all parties concerned that those gentlemen should relinquish the post, and that others should be appointed in their place. It was a subject of most anxious consideration with the Board for some time, they having the names of several eminent firms of solicitors before them; but ultimately it was decided to appoint Mr. Snell, of the firm of Messrs. Snell, Son, and Greenip, a step which he trusted would meet with the approval of the shareholders. Another thing the committee had had to do was this, they had had certain claims made upon them, and, as the meeting knew, there was no money to meet them, and rather than call the shareholders together to give them power to make a call to pay those claims, and so wash their dirty linen in public, they had put their hands into their own pockets and made the payments, and thus kept the affair going. He need not tell the meeting that they had not to took very far into the affairs of the company before they found that M. Philippart was certainly a very great debtor to the Company. They at once wrote to the syndic at Paris who was managing his bankrupt affairs, informed him what claims the Company had, and after doing that they placed their affairs in the hands of an *avoué* in France. He informed them that as a committee they had no power to take legal proceedings as in England, and if they wanted to recover anything in the bankruptcy they must at once get somebody appointed who would stand in a legal position as the representative of the Company. That was one of the reasons why they had taken the step they had done for presenting a petition for winding up compulsorily. Another reason was that they had letters from different creditors which left no doubt in his mind or in that of the majority of the committee that if they had not presented the petition themselves some of the creditors would have done so, and the liquidation would have fallen into hands which he for one would have been very sorry to see. They therefore felt that the only course open to them was to present a petition for voluntary liquidation, getting a provisional liquidator appointed who would be in a position to carry on the affairs of the Company, and having done so they would have breathing time, so to speak, to look round and place before the shareholders the true state of matters, and take their opinion as to whether they should go on with the compulsory liquidation, or whether they should have a voluntary one. He need hardly say that if they went into a voluntary one an immense amount of expenditure was saved. Every step taken with regard to a compulsory liquidation was taken, so to speak, under an order of the Court, which could not be got under several guineas, whereas if they had a voluntary liquidation the liquidator had simply to act on his own responsibility, and whenever he was in any difficulty to go to the shareholders, and if they could not determine what to do he could fall back on the Court and get its orders. Under these circumstances he thought it would be best to pass the resolutions contained in the notice convening the meeting.

A brief and unimportant discussion ensued, in the course of which the advantages of the voluntary system of liquidation were duly set forth by Mr. L. A. Solomon and others.

The following resolutions were finally adopted, with but very few dissentients:—"That Messrs. Harcourt-Turner, Wm. D'Oyly, and Edward Ponsonby be and they are hereby appointed directors of the Company."—"That a sum of 80 guineas be given to the directors as a remuneration, it being understood that this amount should be divided among the committee as well as among the directors," and "that the Faure Electric Accumulator Company (Limited) be wound up voluntarily under the provisions of Section 129 Sub-section 2 of the Companies Act, 1862."

A vote of thanks to the chairman and the committee having been passed the proceedings terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. June 18.		Business Done Week Ending June 18. Highest.	Lowest
Anglo-American	31,	32	32⅛	31½
Do. Preferred	55,	56	57½	55¼
Do. Deferred	6½,	7	7	6 11-16
Brazilian Submarine	9⅞,	10⅛	10 1-16	10
Cuba	9¾,	10¼	10	9⅞
Do. Preference	16½,	17½	—	—
Direct Spanish	4½,	5	—	—
Do. Preference	14¼,	14¾	14¼	—
Direct United States Cable	9⅝,	9⅞	9 15-16	9 13-16
Eastern Telegraph	11⅛,	11⅜	11 5-16	11
Do. 6 per Cent. Preference	13¼,	13¾	13¾	13½
Do. 5 per Cent. Debentures, 1899	103,	107	—	—
Eastern Extension	11¼,	11½	11½	11⅜
German Union	9¼,	9¾	—	—
Globe Telegraph and Trust	6½,	6¾	6⅝	6½
Do. Preference	12¼,	12½	12½	12 5-16
Great Northern	13⅞,	14⅛	14⅛	14
Indo-European	30½,	31½	—	—
Mediterranean Extension	1¼,	1¾	—	—
Do. Preference	2,	4	—	—
Reuter's	8,	8½	—	—
Submarine	153,	158	157	154½
West India and Panama	¾,	1	13-16	—
Do. 1st Preference	6¼,	6¾	6¼	—
Western Brazilian	5¼,	5½	5 15-16	5 7-16
Western Union 7 per Cent. 1st Mortgage	121,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	106	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅛,	¼	—	—
Oriental	⅛,	⅜	—	—
United Telephone	9,	9½	9½	8½

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1⅝,	1⅞	—	—
Do. (fully paid)	3¼,	3¾	—	—
Hammond Light (£3 15s. paid)	½,	¾	9-16	—
Eastern Electric (£4 paid)	—	—	—	—
Swan	⅜,	⅝	—	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	32½,	33½	33⅛	32¼
India Rubber, Gutta Percha, and Telegraph Works	19½,	20½	21	19

TRAFFIC RECEIPTS FOR MAY, 1884.

Companies.	May, 1884.	May, 1883.	Increase.	Decrease.
Cuba Submarine	2,950	3,376	—	426
Direct Spanish Telegraph	1,562	1,641	—	79
Direct United States	—	—	—	—
Eastern Extension	35,910	32,156	3,754	—
Eastern Telegraph	51,537	42,960	8,577	—
Great Northern	24,920	—	—	—
Submarine	—	—	—	—
West Coast of America	4,240	—	—	
Western and Brazilian	—	—	—	—

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NOTES.

AN EXHIBITION AT BOSTON, U.S.—There is to be an Electrical Exhibition at Boston this winter.

THE KINETIC ENGINEERING COMPANY.—This company have removed to 37, Brooke-street, Holborn, E.C.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 20th inst. were £2,786.

CABLES REPAIRED.—The cable between Chorillos and Mollendo and that between Pernambuco and Ceara is now repaired.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 20th instant amounted to £3,516.

EARTHQUAKE IN INDIA.—News from India says that a sharp shock of earthquake was felt in Darjeeling and neighbourhood about 10:17 a.m. on May 18.

PROVISIONAL ORDERS.—Electric Lighting Provisional Order Bill, No. 3, passed through Committee, and was reported to the House of Lords on Tuesday.

FRENCH ACADEMY OF SCIENCES.—M. Jamin this week assumed the post of perpetual secretary to this academy, to which he was elected a few days since.

TELEGRAPH REVENUE.—The receipts from the Post Office Telegraphs from 1st April to 24th June were £355,000, compared with £350,000 for the same period of last year.

THE GAS ENGINE.—According to Prof. Dewar, a gas engine of 2 or 3 horse-power is more economical than a steam engine of the same power; but for higher powers this is not the case.

GILCHRIST ENGINEERING SCHOLARSHIP.—At University College on Wednesday, the Gilchrist Engineering Scholarship, £35 per annum for two years, was awarded to R. F. Hayward, of Harrow.

GALICIA.—Owing to heavy floods, telegraphic communication between Cracow and Lemberg and other towns in Galicia and Moravia was interrupted last week, and we believe still remains so.

ELECTRIC ASSOCIATION.—A general meeting of this company is to be held at Hatton-court, Threadneedle-street, E.C., on the 25th proximo, to receive the liquidator's account of the winding up.

EASTERN EXTENSION TELEGRAPH COMPANY.—The directors of this company have declared an interim dividend for the quarter ended March 31 last of 2s. 6d. per share, free of income-tax.

THE J. B. ROGERS COMPANY.—Creditors of this company are requested to send their claims, &c., to Mr. F. G. Painter, 2, Moorgate-street-buildings, E.C., the official liquidator, before the 14th proximo.

POSTAL TELEGRAPHS.—According to the Civil Service Commissioners' Report for 1883, just issued be it noted, there were 1,848 candidates for 160 vacancies among male and female telegraph learners.

ELECTRIC LIGHTING IN LEIPZIG.—The gas company at Leipzig intends, says a contemporary, to ask the Municipal Council of that town for a concession for lighting the streets and houses by electric light.

THE NEW ATLANTIC CABLE.—A message from Lloyd's states that the steamer "Faraday," from London for Halifax, passed the Lizard at 2:10 p.m. on Wednesday, to complete the laying of the new Atlantic cable.

SOUTH KENSINGTON MUTUAL ELECTRIC LIGHTING COMPANY.—Mr. Justice Kay has fixed 12 o'clock on Wednesday next, at the Royal Courts of Justice, for the appointment of an official liquidator of this company.

HYGIENIC AND ELECTRIC ASSOCIATION.—At a meeting of this association, held at 285, Lake-road, Landport, on the 7th inst., it was resolved to wind up voluntarily. Mr. H. R. Viggers has been appointed liquidator.

TELEPHONE WIRES IN CHICAGO.—There are 500 miles of wire in use in this city. The authorities are beginning to have them put underground. Sixty miles will be laid this year under the superintendence of Professor Barrett.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The coupons due on Monday next on the debentures of this company will be paid by Messrs. Barclay, Bevan and Co. The coupons must be left three clear days for examination.

ELECTRIC LIGHTING IN THEATRES.—There are 2,862 lamps in the Edison installation in the Teatro della Scala, at Milan, this being perhaps the largest installation of its kind in existence. It has been running since last winter without the slightest hitch.

THE FORTH CABLE.—On Tuesday telegraphic communication was all but stopped by the breakdown of the Forth telegraphic cable, supposed to have been caused by the anchor of some vessel having come in contact with it. Partial communication was restored at a late hour.

INTERNATIONAL PATENTS.—According to a statement recently made by Mr. Chamberlain, efforts will be made to complete the necessary formalities for enabling the terms of the International Convention for the Protection of Patents to take effect on July 7th.

"FREE COMPETITION!"—We are informed on very good authority that the United Telephone Company have bought up the London and Globe Telephone Company, an arrangement which we need hardly say will result in a practical monopoly over a very considerable telephone area.

ELECTRIC LIGHTING IN MALVERN.—The establishment of Messrs. H. and F. Davis, art screen manufacturers, Waterloo House, Malvern, is now lighted by Swan incandescent lamps. A Ferranti dynamo, excited by a small Siemens machine, supplies the current. Messrs. Davis are agents for the Hammond Company.

THE PARIS FIRE BRIGADE.—According to a recent report of the French Prefect of Police relating to the organisation of the Paris Fire Brigade, there are 190 stations in telegraphic communication with the chief offices and where the alarm of fire may be given, the telegraphic wires in use extending to a total length of 350 kilometres (about 220 miles).

QUICK WORK.—A somewhat remarkable example of the use of the telegraph was witnessed on Monday night in the House of Commons. While Mr. Gladstone was delivering his speech, says the *Standard*, many of the members were in possession of a summary of M. Ferry's statement delivered two hours before, and were able to compare it with Mr. Gladstone's.

WEATHER REPORTS AND THE HARVEST.—It appears that farmers who wish to have telegraphic weather reports from the Meteorological Office during harvest time can do so by paying a shilling for each telegram. If copies of the same telegram are

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taken by other farmers in the same delivery district the cost of each additional copy will only be threepence.

SOCIETY OF ARTS.—The council of this society have awarded a silver medal to the authors of the following papers read during the last session:—Professor Fleeming Jenkin, F.R.S., for his paper on "Telpherage;" Mr. I. Probert, for his on "Primary Batteries for Electric Lighting;" Professor Silvanus P. Thompson for his on "Recent Progress in Dynamo-Electric Machinery."

ELECTRIC LIGHTING IN STUTTGART THEATRE.—The plant in this installation consists of 4 boilers and 2 engines capable of working up to 100 horse-power and making 130 revolutions per minute. The latter drive four Edison K dynamos, whilst an E dynamo is driven by a separate and smaller engine. The total number of lamps, 32, 16, and 10 candle-power, distributed throughout the theatre is about 880.

QUICKSILVER MINES.—According to Mr. J. B. Randol, of San Francisco, there were about thirty mines in California producing quicksilver in 1876. Many of these were only experiments. The locators were unable to make any money out of the business, and so suspended operations. Out of the twenty-seven mines that have produced quicksilver in the last eight years only five are known to be in operation now.

DONATIONS TO THE CITY AND GUILDS INSTITUTE.—The following additional donations to tne equipment fund of the Central Institution have been voted in response to the appeal of his Royal Highness the Prince of Wales:—The Goldsmiths' Company, £4,000 (subject to confirmation); the Salters' Company, £525; the Cordwainers, £250; and the Plasterers have increased their annual subscription from fifty guineas to £100.

UNITED TELEPHONE COMPANY.—The directors of this company have decided, subject to audit, and after making provision for depreciation, &c., to recommend at the forthcoming annual general meeting a dividend for the second half year ending April 30, 1884, at the rate of 5s. 6d. per fully paid share, part paid shares receiving in proportion, making, with the interim distribution in January, a total dividend for the twelvemonths ending April 30 last of 8 per cent. per annum.

A SHIP STRUCK BY LIGHTNING.—A despatch from Derry, dated 22nd inst., says:—"Captain M'Cann, master of the Derry barque 'Village Bell,' arrived in port this evening from Baltimore. He reports having eight sailors on board belonging to the Spanish ship 'Angeleta,' from New Orleans to Barcelona, which was struck by lightning and set on fire." The message states that the whole of the crew were rescued, and makes no mention of any casualty amongst them. The ship appears to have been burnt to the water's edge.

CASSELL AND CO.'S PUBLICATIONS. — *Cassell's Technical Educator* contains articles on "The Electric Telegraph," "Technical Drawing," "Applied Mechanics," &c. *Cassell's Family Magazine* for this month has an article on "Our Earthquake Experiences," which refers to the recent earthquake in Essex, besides the usual excellent miscellaneous articles and serial stories. "The Gatherer" columns of the same magazine contain notes on "A Watch Demagnetiser," "Electric Light Conductors," "A Cheap Lightning Rod," "New Applications of the Electric Light," &c.

MUIRHEAD'S DUPLEX SYSTEM.—A report of the case of Muirhead *v.* the Direct United States Cable Company, in which the plaintiff sued the defendants for arrears of royalty for the use of plaintiff's duplex system, will be found in another column. A fault was discovered in the cable some time since, which rendered duplex working impossible, though simplex working could be continued. The defendants therefore refused to pay the plaintiff's royalty. The whole question turned on the construction to be placed upon the words "operate satisfactorily" contained in an agreement between the parties. The judge gave judgment for the plaintiff, but stayed execution.

THE ROYAL ACADEMY.—The President and Council of the Royal Academy of Arts held their annual *conversazione* on Wednesday night in the galleries at Burlington House. Perhaps, says *The Times*, from a chivalrous regard on the part of the council for those artistically compounded complexions which Mr. Malcolm Morris has so severely criticised, the yellowish-red flare of gas was not replaced by the pure white glow of the incandescent electric light, so that since it was impossible under such conditions to look at the pictures with any pleasure, it follows, as of course, that the people who thronged the rooms were the chief attraction of the evening.

CABLE BETWEEN JAPAN AND THE KOREA.—The following notice to mariners has been issued by the Admiralty:—"A cable has been laid in Korea Strait from Kotomura (lat. 33° 32¾′ N., long. 129° 55½′ E.), north-west coast of Kiusiu, Japan, to Tsau-liang-hai (Fusan or Chosan Harbour), south-east coast of the Korea. The cable is landed at intermediate stations on Iki Sima and Tsu-sima. From Kotomura it is laid between Kagara Sima and Oögawa Sima to the eastern shore of Go no Ura (Gonolbra), Iki Sima; thence to Itsuhara Harbour, on the east coast of Tsu-sima; and finally from Komada (Komotamura), on the west coast of Tsu-sima, to the Japanese Station at Fusan. In the inner part of Fusan Harbour the cable is marked by buoys."

THE SUNDA STRAITS DISASTER.—Mr. R. D. M. Verbeck, a mining engineer in the service of the Netherlands Indian Government, who was commissioned in October last to inquire into the recent volcanic disturbances in the Sunda Straits, is of opinion that the volcanic character of Krakatau and the country in its neighbourhood arises from the fact that a cleft exists in the earth's surface at that point which admits of the admission of water into the interior of the earth. The water coming in contact with molten matter generates steam, which he thinks is the prime mover in most if not all volcanic eruptions. Mr. Verbeck estimates that a circle described from Krakatau with a radius of thirty degrees, or 2,080 miles, would pass through the farthest places where the tremendous reports which accompanied the eruptions were heard.

EARTHQUAKES IN ENGLAND.—In a recent paper read before the North of England Institute of Mining and Mechanical Engineers by Professor Lebour, the author dealt with the series of earthquakes which have been felt in Sunderland from December, 1883, to the present time. He thinks that falls of cavern roofs at moderate depths in the magnesian limestone, which is much fissured and hollowed out by the action of water, are sufficient to account for the shocks felt. Another paper by Mr. M. W. Brown endeavoured to show the connection between earth tremors and sudden outbursts of fire-damp in mines. He thinks that there are many cavities in the earth's crust filled with gas, which escapes when an earth tremor occurs through fissures opened by this means, and that if this happens in the neighbourhood of a mine the result is an outburst of gas into the latter.

THE TELEPHONE AND THE POST OFFICE.—In consequence of the attitude assumed by the Government towards the proprietors of telephones, says the *Daily Telegraph* of Saturday last, Mr. Jacob Bright intends, when the vote for Post Office

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telegraphs comes before the House, to move: "That the telephone having become indispensable for purposes of public business the public interest requires that the telephone companies should, after paying a reasonable royalty to the Post Office Department, be absolutely free in the conduct of their business, it being understood that communication must be by conversation and not by messages in the place of the telegraph." From another note in this week's issue it will be seen that Mr. Fawcett has expressed his willingness to consider any suggestions that may be made by the telephone companies.

TELEPHONE COMPANIES.—In the House of Commons, on Tuesday, Mr. Fawcett, in reply to Mr. Slagg, said:—I am frequently asked by the various telephone companies to modify in different respects the existing terms on which they carry on business. I am therefore about to propose that the telephone companies should meet and endeavour to come to an agreement as to the modifications of those terms which in their opinion would meet the public requirements. Should they act upon this suggestion and communicate the result to me in writing, their proposals shall at once be carefully considered, with every desire to allow the greatest freedom possible to telephonic communication which is compatible with due protection of the interests of the revenue. In answer to Mr. Gray, the right hon. gentleman added that should he receive from the telephone companies such a communication as he referred to he would do his best to come to a decision upon it as soon as possible.

ELECTRIC LIGHTING OF THE HOUSE OF LORDS.—In the House of Lords, on Thursday, the 19th inst., Lord Greville asked whether any steps were about to be taken as to the lighting of the House by the electric light; also, having in view the great importance of obtaining the best and most economical results, whether Her Majesty's Government would ask the leading companies in Great Britain to tender for the same. Lord Sudeley: In reply to the noble lord, I am unable to say exactly when the House and the libraries will be lighted by the electric light, but the First Commissioner of Works has at present the lighting of both Houses under his consideration. As a considerable amount of money will have to be expended, the plans connected with it naturally require most careful looking into; and as a portion of the work has been carried out by one company, the First Commissioner is unable to say to what extent it will be possible to invite public competition, but he hopes he may be able to do so.

GAS AND ELECTRICITY IN FRANCE.—The eleventh annual Congress of the Société Technique de l'Industrie du Gaz was held at Paris on the 17th and 18th of June, under the presidency of M. Marché. Four medals were conferred on the authors of communications relating to gas and electricity, and amongst the recipients were M. Delahaye, for his paper on "L'Industrie de l'éclairage electrique en 1883," and M. Monnier for four papers on "Photometrical Standards," "The Napoli Photometer," "The 8 Horse-power Otto Motor," and the "Siemens Electrical Pyrometer." The expenses of maintaining M. Monnier's electrical laboratory are, says the *Révue Industrielle*, defrayed by certain gas companies. In the course of his presidential address, M. Marché paid a tribute to the late M. Dumas, and proposed that his name should be given to the photometric standard adopted by the International Conference of Electricians. "Gas engineers are," he said, "labouring to become electricians, they acquire from the latter whatever of the practical there is in their discoveries, and the result will be that gas will come out of the struggle more powerful than ever."

THE PLATINUM STANDARD.—In the course of a recent lecture at the Royal Institution, Professor Dewar made some remarks relative to the new photometrical standard recently adopted at Paris. He stated that as platinum grows hotter the relative proportions of red and green rays emitted by it vary, the following being the results obtained from some experimental researches of his own on the light radiation of the metal:—

Temperature. Deg. cent.	Luminous intensity. Red rays.	Green rays.
954	1·00	1·00
1045	3·27	3·64
1500	154·00	219·00
1775	507·00	809·00

He added that the object of the platinum standard is not, as erroneously supposed sometimes, that every man who indulges in photometrical experiments shall carry about a quantity of melted platinum with him, but that this more perfect standard shall be one with which the standard, but imperfect, candles and lamps at present used in photometric work may be compared. The French Carcel lamp, he added, is decidedly a more perfect instrument for measuring luminous intensity than the English standard candle. The last temperature given in the foregoing table, 1,775 centigrade, is close upon the melting point of platinum, and in measuring the intensity of light, mean white light is chosen, not individual rays.

EXHIBITION AT ANTWERP.—The committee for organising the electrical section of the proposed Universal Exhibition at Antwerp in 1885 has been definitely constituted. Amongst the members we notice the names of MM. Banneux, chief engineer of Belgian Telegraphs; De Cazenove, chief of the Technical Department of the Belgian Bell Telephone Company; Gérard, of Liege University; Jaspar, electrical engineer of Liege; Melsens, member of the Brussels Academy of Sciences; Mourlon, Nothomb, Rousseau, Somzée, Van Rysselberghe, and Wybauw, of Brussels, all well known names in connection with electrical science. The committee has been divided into four sections. The first section, presided over by M. Rousseau, will deal with the study and teaching of electrical science. Section 2, with M. Delarge presiding, will concern itself with the transmission of signals and words by means of electricity. The third section, of which M. Somzée is president, will concern itself with the production of electric currents and electric lighting; and the fourth section, presided over by M. Melsens, will deal with general mechanics, electric conductors, and the application of currents. It is proposed to light the principal portions of the exhibition by means of the electric light, and to provide for the telephonic transmission of music and theatrical performances from Brussels, Ghent, Liege, or perhaps Verviers, to the exhibition at Antwerp. The scheme also includes the trial of electric launches in the Scheldt, and the propulsion of tramcars in Antwerp by electrical means.

A NEW DYNAMO.—At a meeting of the Paris Academy of Sciences on the 9th inst. a note by MM. A. Damoiseau and G. Petitpont was read, in which the authors described a new dynamo. They propose to make such modifications in the armature as shall permit of a higher E.M.F. being obtained for a given length of wire traversed by the current. The suggested improvement can be applied to machines of the Pacinotti type, the Gramme, Hefner-Alteneck, and Siemens. The expansions of the inducing poles are suppressed, and these poles approached the one to the other in such a manner as only to influence one portion of the ring, a fourth or eighth part for instance. The current is collected at three points of

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the collector, one practically at the centre of the part corresponding to the portion of the ring influenced, the other two on either side of each pole. The authors have constructed a model, of which the ring in the shape of a disc carries 3·2 kilograms of 1·2mm. wire, and the electro-magnets 18 kilograms of 1·6mm wire. The pole surfaces are only 56cq. for each pole, and influence the ring on both faces. The length of wire between the two brushes is only 45m. With the electro-magnets connected in pairs, a current of 11·7 amperes and an E.M.F. of 64·5 volts is obtained at the terminals at a speed of 690 revolutions. At 1,854 revolutions they get 207 volts with an open circuit, and at 1,900 revolutions 180 volts at the terminals and a current of 23·5 amperes, with a resistance of about 7·5 ohms. The electrical duty under these conditions is ·763, when the machine gives more than 200 watts per kilogram of wire, which is nearly double the work given by present machines.

Electricity in the Lecture Room.—A correspondent of the *Scientific American* writes to that journal as follows:—"Having occasion to illustrate in a lecture some of the phenomena of atmospheric electricity, I desired to obtain as long strokes as possible. With the apparatus at hand the longest stroke I could obtain in air was 4¼in. I tried iron filings sprinkled on varnished glass, paper, and wood, but the results were not satisfactory. After several experiments I hit upon the following exceedingly successful method: I fastened dry boards together to make a plane surface, 4ft. long and 3ft. wide. One side of this I varnished, and before it was dry pressed over its entire surface sheets of tin foil. After letting it stand over night to dry slightly, with a ruler I passed a sharp knife across the foil in lines about ⅛in. to ¼in. apart. Allowing it to dry a short time, I passed the knife across it right angles to the former lines, thus cutting the foil into squares, separated by very short distances—only the thickness of the knife edge. Connecting the poles of my coil to opposite ends of the board, a phenomenon of dazzling beauty was produced. Every time the circuit broke, from 6 to 20 streaks of lightning zigzagged from one end of the board to the other. These were exceedingly brilliant in the dark, when the circuit was broken only about 180 to 200 times a minute. Judging from the resistance of vacuum tubes placed in the circuit at the same time, I believe I can obtain strokes from 15ft. to 20ft. in length by this method, if the foil be placed in a narrow strip along a pole of that length. The drying mentioned above is necessary, as it is very slow under the foil, and the strips will be pulled out of their places in the second cutting."

Electric Lighting at Wimbledon.—The experiments conducted by Mr. Preece at Wimbledon have now been concluded. The results are briefly as follow, according to the *Daily News* of Saturday last:—Taking 10 candles as the average effective illumination given by five cubic feet of gas in a street lamp, the cost works out to ¼d. per lamp per hour for incandescent lighting. The most efficient mode of distributing light in a street appears to be to hang a 50 candle-power lamp about 20ft. above the centre of the road at every 100ft. For reflecting purposes a polished nickel-plated iron surface of a slightly convex form and Trotter's dioptric system gave the best results. Our contemporary gave some information as to the lighting of Mr. Preece's house which is interesting:—"The motive power is derived from a gas engine of two horse-power; and one of the chief features is a very low electromotive force, by which danger to person from shocks is entirely eliminated. The pressure is only 25 volts, which is imperceptible; so that the wires and machines can be freely handled. Another important feature is the use of Planté's secondary cells as a regulator to the gas engine. By this absolute steadiness of light is ensured. Thirdly, there have been introduced the employment of movable fixtures, so that the electric light becomes as portable as candles or oil lamps. The lamps used are little (Woodhouse and Rawson) 10-candle lamps of extreme brilliancy. The effects are quite fascinating. Mr. Preece has carried the system so far as to illuminate his little daughter's doll's house with four 'fairy' lamps, while Taylor-Smith's portable lamps enable him to examine his greenhouses or his garden at night as by day."

The Electro-Deposition of Iridium.—In the course of a recent paper before the Boston U.S. Society of Arts, Mr. John M. Batchelder says:—"While engaged in some details relative to the engraving and printing of the charts issued by the Coast Survey in 1857, it occurred to me that engraved copper plates might be improved by the electro-deposition of a metal harder than the copper upon the surface of the plate, the object being the protection of the surface from oxide, greater durability, ease of wiping, and a retouching of the lines. I could hardly hope that the process would be applicable to the very fine intaglio lines, but it was found that they were uninjured, the deposit taking place first upon the prominent edges or borders of the lines, and not in the cut. The metal selected for this purpose was iridium, which was procured from the United States Mint. The solution for the bath is prepared as follows: Iridium and osmium, which have been separated from other ores, are fused with about three times their weight of nitrate of potass for about one hour, at a bright red heat, and the contents of the crucible poured upon an iron plate. After cooling, the mass is broken into small pieces, which are then to be treated with nitric acid in a glass retort having a condenser, by which the osmium is separated in the form of osmic acid; the iridium remaining in the retort is to be treated with hydro-chloric acid after removing the nitrate of potass by crystallization, and we then have the chloride of iridium. The solution should contain about one-eighth of an ounce of iridium to a gallon of water, to which about one-quarter pound of sulphuric acid should be added. The plate, when immersed in solution, is connected with the battery in the usual manner. On its removal from the solution it is found coated with iridium in the metallic state, and closely resembling the common steel plates."

Spectra of Silicon Fluoride and Hydride.—In a recent number of *Wiedemann's Annalen*, Herr K. Wesendonck had an article on this subject, the following abstract of which appears in the *Jour. Chem. Soc.* for June:—"As the author observed in a bought Geissler tube containing silicon fluoride the spectrum of carbonic oxide, he examined the result with especial reference to the spectra of silicon compounds, and the cause of the presence of that of carbonic oxide. Silicon fluoride was prepared in the usual way in an apparatus made entirely of glass, and fitted with stopcocks; this was connected with a Geissler tube. The apparatus was first exhausted, then the acid allowed to come in contact with a mixture of pure glass and fluorspar, and the apparatus again frequently exhausted until gas present was in all probability pure. However, with all this care the spectrum of carbonic oxide was always visible, and mixed with that of silicon fluoride. At comparatively high pressures, when the discharge gave a continuous cylinder of light, there was observed a more or less continuous carbonic oxide spectrum with the characteristic eight blue bands of silicon tetrafluoride; with decrease of pressure, the spectrum varied precisely in the same manner as that of carbonic oxide, the eight blue bands became clearer,

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and bands in the violet appeared. With the introduction of a Leyden jar in the circuit, Swan's carbon spectrum became visible. In another form of apparatus, in which the stopcocks and all lubricating material were avoided, the same phenomenon was observed. As the cause was proved not to be due to the action of the gas on the electrode, its probable explanation lies in the great avidity of silicon tetrafluoride for water. If by the contact of the gas with water a little oxygen were set free, the latter would possibly oxidise immediately any trace of carbon containing substances, such as dust, which might be present. The spectrum of a mixture of silicon hydride and hydrogen (formed by Wöhler's process) gave in narrow tubes only the spectra of carbonic oxide and hydrogen; in broad tubes under high pressure a number of lines which were observed in the silicon fluoride spectrum were visible, although the characteristic blue bands were absent; possibly the latter are peculiar to silicon fluoride."

City and Guilds Central Institute.—The Central Institution of the City and Guilds of London Institute was opened on Wednesday by H.R.H. the Prince of Wales, president of the institute. His Royal Highness was received by the Lord Chancellor, Sir Frederick Bramwell, and Sir Sydney Waterlow (the vice-presidents), Sir Philip Cunliffe Owen, Mr. Birkbeck, M.P.; Mr. B. Samuelson, M.P.; Professor Armstrong, Professor Ayrton, Professor Henrici, Professor Unwin, Mr. Philip Magnus, and others. In addressing the Prince the Lord Chancellor referred to the setting of the first column of the building by His Royal Highness on July 18, 1881. He stated that nothing was now wanting for its completion but some internal fittings, towards the provision of which the City and many of the London livery companies had in response to His Royal Highness's request contributed nearly £17,000. The total cost of the building when completed, would, he said, amount to nearly £100,000, and the council confidently trusted in receiving the balance still needed. In 1881 he had said that the number of candidates for the technological examinations was 1,563, as compared with 816 in the previous year; he was now able to state that the number examined in May of this year was 3,628, as compared with 2,322 in 1883. Referring to the work of the Royal Commission on Technical Instruction and their visit to the Continent, he said that they were able to report after three years' labour that no organisation like the City and Guilds Institute existed on the Continent, and that the opportunities afforded to workmen in this country to obtain by means of evening classes sound technical instruction compared favourably with those enjoyed by the same classes abroad. His Royal Highness in reply assured his hearers of the pleasure it gave him to be present, and his warm interest in the work of the Institute. Other speeches having been delivered, and thanks voted to the City and Livery companies, the officials and professors were presented to his Royal Highness, and the proceedings closed. We have received a copy of a pamphlet written by Professor Ayrton, entitled "A Short Notice of the City and Guilds of London Institute for the Advancement of Technical Education," written on the occasion of the opening of the Central Institution. It contains a short history of the foundation of the institute, its objects, some details of the instruction imparted and the methods of teaching employed, and other information of interest in this connection.

Electric Lighting on Ships.—The following extracts from a Government report made by Lieut. Seaton Schroeder, U.S.N., on the electric light on the U.S. Fish Commission steamer "Albatross," will be read with interest:—There are 136 Edison incandescent lamps on board; of that number, under ordinary circumstances, 40 to 45 are generally in operation the greater part of every evening, beginning at dark and ending at about 11 p.m. During the quarter ending March 31, 1883, 18 lamps have been disabled, as follows:—10 broken in handling, 4 burned out, 1 burned out by short circuiting of two branch wires, 1 gradually unscrewed from socket owing to vibration of hull, and fell on deck, breaking the glass and filament; 1 carbon filament broken by caulking the deck above, 1 carbon filament broken while experimenting. The invoice price of each lamp being 1 dol., the additional cost of illumination on account of breakage of lamps has been 18.00 dols. over and above first cost of plant. During the quarter the dynamo machine has run 540 hours. Of the 136 lamps in position 34 have been in operation the whole time, or 540 hours each = 18,360 hours in all; of the remainder, the hours of incandescence have been as follows:—

2—440 hours each	....	=	880	hours.
4—410 " "	....	=	1,640	"
22—340 " "	....	=	7,480	"
8—100 " "	....	=	800	"
20— 50 " "	....	=	1,000	"
18— 10 " "	....	=	180	"
		=	11,980	
34—540 " "	....	=	18,360	"
Total	....	=	30,340	"

The running expense in lamps has therefore been $\frac{18 \text{ dols.}}{30,340}$ = 59 one-thousandths of a cent per lamp in operation per hour. For illuminating the entire vessel the running expense in lamps has been $\frac{18 \text{ dols.}}{540} = 3\frac{1}{3}$c. per hour. The life of the lamps that have burned out has been as follows:—No. 49 (8 candle-power), 92 hours; No. 90 (8 candle-power), 369 hours; No. 68 (16 candle-power), 195 hours; No. 41 (8 candle-power), 99 hours. A mean of these would obviously be a very unfair showing of the average life of the Edison lamp. The imperfect ones give way first, and a correct average, of course, can only be had by waiting to consider the best as well as the poorest. It is only fair also to add that the breakage by accident has been greater than will probably continue to be the case, the crew being extremely raw, green, and unthinking. In handling the lamps—frequently without authority—they have apparently used more force, as a rule, and less dexterity than the occasion required, simple as their manipulation is. Familiarity with the light will doubtless decrease this source of expense. Furthermore, the lamp that was disabled by caulking over head was purposely left in place to test its safety under those conditions, it being attached to the deck that was being caulked. The burning of one by short circuiting occurred before the installation of the system was completed, and resulted from the loose ends of two branch wires coming in contact. The destruction of a third occurred during, and was apparently caused by, some experiments, which proved an abnormal condition for an incandescent system of illumination. As shown above, only four of the eighteen have burned out, which would reduce the legitimate running expense to $\frac{4 \text{ dols.}}{30,340} = 13$ one thousandths of a cent. per lamp in operation per hour, or $\frac{4 \text{ dols.}}{570} = 74$ one-hundredths of a cent. per hour, for lighting the vessel. Some of the globes have begun to be discoloured by the wasting of the filaments—Crooke's effect—but not sufficiently to affect sensibly the amount of light given out. Apart from questions of economy, the light commends itself strongly for use on shipboard.

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ELECTRO-CHEMISTRY.—Inorganic.

BY DR. G. GORE, F.R.S.

(CONTINUED FROM PAGE 126.)

Separation of Aluminium.—Al. Electro-chemical equivalent $= \frac{27 \cdot 5}{3} = 9 \cdot 16$. A triad cation. Magnesium by simple immersion in solutions of aluminium salts produces aluminic hydrate (S. Kern, *Chem. News*, Vol. XXXIII., p. 236). Magnesium does not deposit aluminium as metal from its solutions (Roussin, *Chem. News*, Vol. XIV., p. 27). An amalgam of aluminium is formed by contact of the metal with sodium amalgam and water (Watts's "Dictionary of Chemistry," Vol. III., p. 886).

Various persons have stated that aluminium cannot be deposited by the aid of a separate electric current. "The electrolytic reduction of aluminium may be performed either in the wet or in the dry way. The reduction from the fused chloride of aluminium and sodium was first effected by Bunsen in 1854. The salt is introduced in a fused state into a red hot porcelain crucible, divided into two parts by a porous earthenware diaphragm, and the extremities of the poles of a Bunsen battery of ten elements are introduced into the two halves of the fused mass. The metal is then reduced at the cathode, and if the temperature is sufficiently high the metal is melted into globules" (Watts's "Dictionary of Chemistry," Vol. I., p. 152).

M. H. St. Claire Deville says:—"It appeared to me impossible to obtain aluminium by the battery in aqueous liquids. I should believe this to be an impossibility if the brilliant experiments of M. Bunsen on the production of barium did not shake my conviction. Still, I may say that all processes of this description which have recently been published for the preparation of aluminium have failed to give me good results. It is of the double chloride of aluminium and sodium, of which I have already spoken, that this decomposition is effected. The bath is composed of two parts by weight of chloride of aluminium, with the addition of one part of dry and pulverised common salt; the whole is mixed in a porcelain crucible, and heated. The combination is effected with disengagement of heat, and a liquid is obtained which is very fluid at 392°F., and fixes at that temperature. It is introduced into a vessel of glazed porcelain, which is to be kept at a temperature of about 392F. The cathode is a plate of platinum on which the aluminium (mixed with common salt) is deposited in the form of a greyish crust. The anode is formed of a cylinder of charcoal, placed in a perfectly dry porous vessel, containing melted chloride of aluminium and sodium. (The densest charcoal rapidly disintegrates in the bath, and becomes pulverulent, hence the necessity of the porous vessel.) The chlorine is thus removed with a little chloride of aluminium proceeding from the decomposition of the double salt. This chloride would volatilise and be entirely lost if some common salt were not in the porous vessel. The double chloride becomes fixed, and the vapours cease. A small number of voltaic elements (two are all that are absolutely necessary) will suffice for the decomposition of the double chloride, which presents but little resistance to the electricity. The platinum plate is removed when it is sufficiently charged with the metallic deposit. It is suffered to cool, the saline mass is rapidly broken off, and the plate replaced" (*The Chemist*, New Series, No. XIII., October, 1854, p. 12). By the electrolysis of fused sodic aluminic chloride the aluminium deposited contains silicium derived from the charcoal electrodes (Deville, Watts's "Dictionary of Chemistry," Vol. I., p. 152, and Vol. V., p. 267).

According to A. Bertrand, by means of a separate current aluminium is deposited on a copper plate in granules from aluminium ammonium chloride, whilst chlorine is evolved at the anode (*Jour. Chem. Soc.*, 1877, Part I., p. 161. *Chem. News*, Vol. XXXIV., p. 227). M. Corbelli deposits the metal by electrolysing a mixture of rock alum, or sulphate of aluminium, and the chlorides of calcium or of sodium, the anode being formed of iron wire coated with an insulating material, and dipping into mercury placed at the bottom of the solution, and the cathode of zinc immersed in the solution. Aluminium is then deposited upon the zinc, and the chlorine which is eliminated at the anode unites with the mercury and forms calomel (Watts's "Dictionary of Chemistry," Vol. I., p. 152).

Thomas and Tilley state that they deposit aluminium from a solution composed of freshly precipitated alumina dissolved in boiling water containing cyanide of potassium; also from a solution of calcined alum in aqueous cyanide of potassium, and from several other liquids. They also state that they have deposited alloys of aluminium and silver, aluminium, silver, and copper; aluminium and tin; aluminium, silver, and tin; aluminium and copper; aluminium and nickel; aluminium and iron, &c. J. B. Thompson says that he has for more than two years been depositing aluminium on iron, steel, and other metals, at a temperature of about 500 F., and also depositing aluminium bronze of various tints from the palest yellow to the richest gold colour (*Chem. News*, Vol. XXIV., p. 194). Jeancon deposits the metal from an aqueous solution of a double salt of aluminium and potassium of specific gravity 1·161, at a temperature of 140° F., by means of a current from three Bunsen's cells (*Telegraphic Journal*, Vol. I., p. 308). T. Ball also deposits it from the double chloride of aluminium and potassium (*Chem. News*, Vol. V., p. 153).

I electrolysed a strong solution of aqueous fluoride of aluminium, containing free hydrofluoric acid, with large sheet platinum electrodes and a strong current. Gas was evolved freely from the anode, and the liquid became heated.

Aluminium used as an anode in dilute sulphuric acid largely stops the current, probably by becoming coated with a layer of insulating oxide; but if employed only as a cathode it is not thus affected (*Chem. News*, Vol. XXXI., p. 99; *Telegraphic Journal*, Vol. III., p. 59).

It may be superficially coated with mercury by being made the cathode in contact with mercury in acidulated water (Cailletet, *Comptes Rendus*, XLIV., p. 1,250; also Watts's "Dictionary of Chemistry," Vol. VII., p. 54).

Aluminium, like magnesium, has great power in reducing metallic solutions and depositing their metals by simple immersion process; it reduces those of silver, mercury, copper, lead, thallium, and zinc (*see* A. Cossa, Watts's "Dictionary of Chemistry," Vol. VII., p. 54).

For the use of electrolysis in the metallurgy of aluminium, *see* F. Fischer, *Jour. Chem. Soc.*, Vol. XLIV., 1883, p. 399. For the electrolytic analysis of compounds of aluminium, *see* V. Francken, *Chem. News*, Vol. XLVI., p. 106; also *Jour. Chem. Soc.*, Vol. XLII., 1882, p. 132; and A. Claessen, *ibid*, p. 896.

Separation of Glucinum.—Gl. Atomic weight = 9·3. A cation. Nilson and Petterson were unable to separate this metal by the separate current method (*Chem. News*, Vol. XXXVII., p. 195). Becquerel deposited the pure metal from a concentrated solution of its chloride by means of a current from twenty voltaic cells. It was in the form of brilliant, steel grey crystalline laminæ (Gmelin, "Handbook of Chemistry," Vol. III., p. 293).

For the electrolytic analysis of its compounds, *see* A. Claessen, *Jour. Chem. Soc.*, Vol. XLII., 1882, p. 896.

Separation of Calcium.—Ca. Atomic weight = 40. According to Klauer, calcium amalgam may be formed either by simple immersion of sodium amalgam in solutions of calcium salts, or by passing a strong electric current from those liquids into mercury. Herschel observed that during the electrolysis of a solution of calcic chloride by means of a separate current, the cathode evolved gas and became coated with caustic lime.

This metal was first separated by an electric current during the year 1808 by Sir H. Davy, who obtained it as an amalgam by employing a cathode of mercury. Fremy subsequently electrolysed pure calcic fluoride in a fused state in a platinum crucible. Brisk effervescence occurred in the mass, a gas was set free at the anode, metallic calcium was deposited upon the cathode and became converted into lime by the oxygen of the air. It was difficult to make the observations, and the crucible was soon alloyed and perforated by the action (*The Chemist*, New Series, Vol. II., p. 548).

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Matthiessen electrolysed a fused mixture of two molecules of calcic and one of strontic chloride with a small amount of sal-ammoniac in a porcelain crucible. The anode was of gas carbon, and the cathode was formed by winding a thin iron wire round a thicker one and dipping its end only just into the liquid. The calcium was set free as metallic globules upon the thin wire. He states that the metal deposited upon the cathode by a separate current in a fused mixture of chloride of calcium and the chlorides of potassium or sodium is not calcium (Watts's "Dictionary of Chemistry," Vol. I., p. 715).

Bunsen deposited calcium in a similar manner to that employed for manganese (*see* paragraph on "Separation of Manganese"), except that he used a greater density of current. He acidulated a concentrated and boiling hot solution of the chloride with hydrochloric acid, poured the boiling liquid into the porous cell, and employed as a cathode an amalgamated platinum wire. The calcium was deposited as a grey layer upon the amalgamated surface. The process is difficult, because the calcium quickly oxidizes to a layer of lime, which covers the cathode and stops the current. The deposit must be frequently removed, and the wire freshly amalgamated each time before re-immersion; and even then but a small amount of the metal is obtained (*The Chemist*, New Series, Vol. I., Part 2, p. 686, August, 1854).

(TO BE CONTINUED)

INCANDESCENT LIGHTING.

BY T. H. SEYMOUR HAWKER.

As the electric light is placed more and more fully on a commercial basis as an illuminant it becomes very necessary to formulate and conventionalise a systematic method of installing the necessary conductors and apparatus.

The present incandescent lamps are undoubtedly as yet very far from perfection, being in fact merely in a transitionary stage, but we can safely leave their development to the usual process of evolution, stimulated by competition.

The great adaptability of electrical generators to any required conditions of supply enables us to foresee that the mere question of the best method of installing will remain practically the same, no matter what improvements may take place in the lamps or the energy-source.

We have indeed already seen in the many systems which have come before the public nearly every possible arrangement of lamps in combinations of series and parallel connections to suit machines of different types.

These varied permutations must be regarded more in the light of concessions to the weaknesses of their respective systems than as indicating difference of opinion as to which method of installation possesses the greatest advantages.

It is only to be expected, for instance, that the advocates of a machine best suited to high tension work, failing to obtain single lamps of suitable resistance, should unwillingly consent to adopt an arrangement involving series coupling.

The disadvantages attending any system of series connections are obvious.

All the lamps in a series are mutually dependent, and in the absence of any compact form of high resistance shunt one cannot be switched off without extinguishing the others.

The danger of accidental extinction can be, to a certain extent, obviated by duplicating the lamps, and using an automatic switch in the holder, which cuts in a new lamp on the breaking of either of those in a series.

This has many objections other than mere expense and unsightliness, and is, in fact, quite inadmissible in any system claiming to be adequate to the exigencies of public supply.

There is, moreover, no reason other than the present undeveloped condition of electrical industries (which, by the way, needs only the stimulus of greater national commercial prosperity) why any machine with a *reasonably* high tension should not be used with a logical and coherent system of lamps of suitable resistance connected *all in parallel.*

The complete independence of all lamps in a parallel circuit, together with the ease with which a circuit can be systematically wired and distributed to give very low resistance with any desired arrangement of lamps, makes this system ideally perfect. It is assuredly the parallel circuit which will be prevalent in the future, and I will therefore principally consider the principles involved in the practice of incandescent lighting on this system.

The chief desiderata to be kept in view are good circuit efficiency, equality of E.M.F. at the terminals of all the lamps, economy of copper so far as is consistent with high efficiency, and general simplicity of details, combined with solid workmanship.

The first mentioned electrical attributes depend principally on the amount of copper which economical considerations can afford for the cabling, and the judicious planning of the circuit so as to subdivide the resistance in as many parallels as possible. By looping or joining *both* ends of a pair of branches to the mains, its resistance is halved, and current carrying capacity doubled. In house lighting this device can be very often used with advantage, especially when a large number of lamps are run in a single pair of parallels, as the distribution of E.M.F. is rendered very much more equable.

The general idea of any parallel circuit is that of two metallic extensions of the machine terminals, with ramifications extending in those directions which they would supply the greatest number of lamps, which are simply connected by each terminal to one of the polar extensions.

The conception of this is very similar to the physiological theory of blood circulation. The dynamo corresponds to the heart, and the positive polar extensions to the arteries. The lamps are the nerves supplied by the flow, and the negative polar extension the circuit completing veins.

When this idea is once grasped, the planning of a circuit depends almost solely on the architectural exigencies of the installation, and only very general rules can be laid down for guidance.

Of the greatest importance, especially when the commercial value of a lighting system depends on the economy of power, is the *efficiency* of the circuit. This is the ratio of the energy utilised in the circuit to the total energy supplied by the generator, and is in practice equivalent to *the ratio of the aggregate lamp resistance to the total circuit resistance*, including the generator.

In parallel connection the greater the number of lamps the less their resistance and the larger the current. With a sensible resistance of leads the increase of current will be rather less than directly as the increase of number of lamps, and the energy expenditure on a circuit of constant resistance being as the square of the current will vary nearly as the square of the number of lamps. If, therefore, we wish to have an equal efficiency with a doubled number of lamps we must employ leads equivalent to nearly four times the sectional area.

It should be remembered that each microhm of resistance between the generator and the lamps involves a loss of E.M.F., which increases directly with the number of lamps supplied thereby. Moreover, the generator itself must have an extremely low internal resistance, or the circuit efficiency will be much decreased and the energy wasted thereon will in addition injuriously heat the machine.

When using large currents, in fact, resistance must *everywhere* be minimised, as it in all cases means waste of energy, and by heating the conductors still further increases their resistance, possibly raising them to a temperature which, if permitted, might endanger not only the circuit but any inflammable materials in proximity.

To impress these principles more deeply let us take a practical example. Let us suppose that a building is lighted with 300 incandescence lamps of 20 candle-power, and working with a current of ·63 ampere at 100 volts. The resistance *hot* per lamp will be about 160 ohms, making an aggregate resistance in parallel of ·53 ohm. In order to have a circuit efficiency of 90 per cent., which is the least usually admissible, the total resistance of generator and mains must not be greater than ·06 ohm therefor.

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The internal resistance of a generator of the Ferranti type will be about ·02 ohm, and as this factor cannot be further reduced without involving the construction of a special machine, it becomes necessary to select the conductors, and so plan the circuit that the remaining ·04 ohm may not be exceeded.

It is well to notice here that any resistance added in series to each of the individual lamps would have but little effect on the economy of energy. We can therefore use very small leads to the lamps themselves, so long as a safe limit of temperature is observed, but must keep the mains or those branches leading to groups of lights of ample size.

I have talked of the effects of *current* on resistance, my reason for doing so being that the heating effect is proportioned to the square of the current. Current, however, necessitates expenditure of E.M.F., and it will now be more convenient to consider resistance as expending E.M.F.

In order that all the lamps in a circuit shall burn at equal brilliancy, it is necessary to have either a constant E.M.F. at their terminals, or to grade the resistances of the lamps so that those which, by reason of the resistance of the leads between them and the generator, have a reduced E.M.F. shall make up for the deficiency by carrying an increased current.

It need hardly be said that on any very extended scale the former is the only practicable system, and we therefore see that care must be taken so to place the circuit as to attain uniform conditions at the lamps.

As an illustration let us consider the case of a long row of 100 lamps in simple parallel between the same pair of mains, which, in order to exaggerate the fault, we will take to be composed of single No. 12 B. G. wires. These will of course get very hot, but we will neglect this. Let us suppose the first lamp is 100 feet from the generator, which gives at its terminals a difference of potential equivalent to 61·5 volts. The resistance to the first lamp would only be ·096 ohm, but this will absorb the odd 11·5 volts. If the lamps were of such a resistance as to burn at full candle-power with the current due to 50 volts, the first lamp would then burn well, but the resistance as well as the current will fall off towards the end of the row, till the last lamp will have a very insufficient current. If the lamps be in groups of 10, and the common interval between the groups be 10 yards, the E.M.F. at each succeeding group will be less by the amount of the product of the intermediate resistance into the remaining current. We therefore get the following E.M.F. at the successive groups :—

No.	1	2	3	4	5	6	7	8	9	10
E.M.F.	50	43	39·2	35	32	29·5	27·3	25·3	23·7	22
Current per lamp	1·2	1·19	·94	·85	·775	·71	·659	·61	·57	·537

There are several ways of rectifying this inequality, which seems primarily dependent on the nature of the conductors and their arrangement, but, however, is greatly attributable to the lamps themselves using too much current and too little E.M.F., that is to say, being of too low resistance.

As we increase the E.M.F. in use, any slight variation of value due to lead resistance bears a less ratio to the whole than while driving a similar current previously. The effect on the lamps is therefore much less, other conditions equal; but as the high E.M.F. lamps require less current we have also a saving in the energy expenditure necessitated to drive a current through resistance. We may expect, therefore, to get much better results under the conditions previously stated with 100-volt lamps, which take only ·63 ampere each. The leads from generator to lamps only absorb six volts, and we can thus work with a margin of only 106 volts at the machine, which will give at the respective groups the following values :—

No.	1	2	3	4	5	6	7	8	9	10
E.M.F.	100	96·5	93·3	90	87·4	84·7	82	80	77·5	75·3
Current per lamp	·63	·61	·587	·567	·548	·53	·517	·5	·486	·475

We can decrease the defect indefinitely, therefore, by simply increasing the resistance of the lamps.

High resistances, however, at present mean very thin and weak filaments, although in the recent Bernstein and Cruto lamps there is an attempt to improve this, and we are therefore constrained to rely on a manipulation of the conductors to attain equality by reducing the resistance.

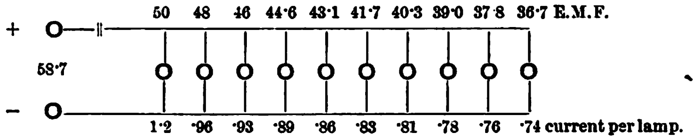
This can of course be done by increasing their weight, but a great deal can be done by subdividing the resistances so as to throw them into multiple arc.

This operation also includes the so called "looping" of circuits, which simply means the joining of a row of lamps to the mains by opposite ends of their leads.

To illustrate this, Fig. 1 gives a plan of the leads for 10 lamps in simple parallel. Fig. 2 shows the same lamps and leads subdivided, and Fig. 3 with the ends looped. The latter can be varied by what may be termed "double looping," in which both ends of each of the lamp leads are carried to the mains, as shown in Fig. 4.

It will be advantageous to analyse these typical elementary circuits, and to compare as a "figure of merit" the ratio borne by the minimum to the maximum E.M.F.'s in the several cases.

Fig. 1.



Single Parallel.

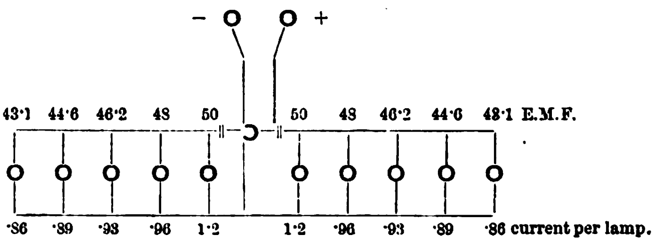
We will take the intermediate resistances for the sake of simplicity as equal, and equal to unity, and the current per lamp as unity also with an E.M.F. of 50 volts ideal. The resistance between the generator and lamps will be assumed at one ohm in each case.

It must be borne in mind, however, that these examples are merely exaggerations of the defects actually met with in practice.

To drive the 10 amperes through the 1 ohm leads will use up 10 volts ; so to get 50 volts at the lamps we must have 60 volts at the generator. The E.M.F. will then be distributed as shown in the diagram.

To give a general formula, let c = necessary current per lamp, r = resistance per lamp, a, b, c, d, e, &c. = the resistance of leads from lamp to lamp. E = E.M.F. of first lamp, n = number of lamps, η = E.M.F. of lamps, and ρ = resistance of leads from generator to first lamps.

Fig. 2.



Divided Parallel.

Then the current will be

$$C = E \cdot \Sigma\left(\frac{1}{r} + \frac{1}{r+2a} + \frac{1}{r+2(a+b)} + \frac{1}{r+2(a+b+c)} \cdot \cdot \cdot \cdot \right)$$

The E.M.F. at any lamp separated from the 50-volt point by a resistance $\beta = a+b+c$ . . . . *in both leads* will be $\eta = E - \left(\frac{E}{r+2\beta} \cdot 2\beta\right)$, and the E.M.F. which the generator must supply $= \epsilon = c\,\rho + E$.

The idea underlying these formulæ is capable of great extension and very general application to calculations of fall of potentials and currents.

Suppose a number of lamps be so arranged along a pair of conductors of resistance $\beta = a+b+c$, &c., so that the resistance to the first lamp being 0, that to the second will be a, the third $a+b$, the fourth $a+b+c$, and so on. Then the current for each lamp will have to pass through these respective

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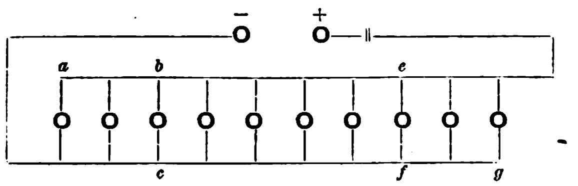
resistances, which will absorb proportionate E.M.F.'s. *The E.M.F. at any lamp is then the E.M.F. at the first lamp, minus the product of the leads resistance into the quotient of the E.M.F. by the total resistance of the circuit through and including the lamp.* We must imagine the total current to be divided into n parts, each equal to $\frac{E}{\Sigma(a+b+c \ldots \&c.)+r}$, and traversing different lengths of conductor to the respective lamps involving a loss of E.M.F. $= c\,(a+b+c.\,\&c.)$.

The simple parallel connection is plainly shown, therefore, to be unsuited to long rows of lamps, and renders a large section of conductor essential if uniformity of illumination is required without graling the lamps.

This uniformity, it should be remembered, is not merely a matter of abstract good appearances, but is vitally connected with the economy of working. If the E.M.F. in a circuit be very unevenly distributed, it will be generally necessary to

Fig. 3.



Single Loop.

burn some of the lamps at too high a candle-power, in order that those further off may give a decent light, and the excess of current simply melts away the lamps affected, shortening their "lives" alarmingly.

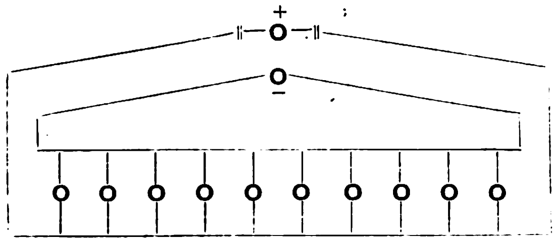
The same sizes of conductor can, however, be arranged for a much better effect, and in a way which is generally more convenient in practice.

In the circuit shown at Fig. 2 the mains are connected to the middle of the row of lamps, and the resistances of the leads are thrown into parallel arc as well as the lamps. The total current, however, still passes through the mains, and the absorption of E.M.F. therein remains as before.

Of course in practice this part of the circuit would be made of large section, so as to reduce the loss.

The range of variation of E.M.F. at the lamps is much less than in the preceding example, and the distribution generally much more convenient.

Fig. 4.



Double Loop.

By placing safety fuses at the points marked ||, this arrangement is also safer than the last, as only half the lights will go out in the event of a short circuit in one of the branches; but more of fuses anon.

The advantages accruing from thus subdividing the leads are so great that it should be a maxim in circuit planning to run "short parallels and many of them."

It is often possible, with a little ingenuity, to attain in this manner an equipotential and low resistance circuit without any further expenditure of copper on the conductors than would be necessary with long parallels and bad E.M.F. distribution. In any case, however, the equality and homogeneiety, if I may use the term, of the lighting should be before all other considerations, and it is therefore better to spend a few additional pounds in doing the cabling well.

It will be obvious that the previous formula can be applied to the calculation of current and E.M.F. at any lamp in this case also, if we take either of the two middle lamps as our starting point, and work outwards,

The single-looped current shown in Fig. 3 is not generally so easy of application as the former, but it has many advantages. We have here the mains connected one to each end of the row of lamps, and there is a tendency to equalise the E.M.F. by the compensation of the resistances of the leads—one increasing as the other diminishes.

The current supplying any lamp has to traverse a length of positive lead *to* the lamp and negative from the lamp, which have a constant sum when added together. Thus, if the mains be equal, the current for $b\ c$ traverses the length $a\ b+c\ g$, which is equal to the distance $a\ e$, $f\ g$, traversed by the current for the lamp $e\,f$, and so on.

The circuit is therefore perfectly equipotential, but it has the disadvantage that the current has to traverse a resistance equal to that to the farthest lamp of the row in every case. A deal of E.M.F., and consequently energy, is therefore lost, if the row be long.

If γ be the resistance of the lead to one end of the row, δ to that of the other, and ϕ the resistance of one of the leads running from first to last lamp, then if a current of c amperes is needed per lamp the generator must have an E.M.F. of $E=c\,(\phi+r+\delta+\gamma)$, and the total current simply $=nc$; while an uniform E.M.F. $= E-c\,(\gamma+\delta+\phi)$ is maintained at all the lamps.

In order to reduce the wastefulness of the leads in this method the system of "double-looping," shown in Fig. 4, may sometimes be employed with advantage when the circumstances connected with architectural design and distribution of lights will permit.

The writer has used the method advantageously in wiring the lights round the front of the balconies and circles of theatres where the ends of the parallel of lamps are not far apart. When, however, this is not the case the extra expense of mains may render its adoption unadvisable.

The leads are here duplicated and their resistance halved, but by so doing we have a falling off of E.M.F. towards the centre.

(To be continued.)

CORRESPONDENCE.

THE NATURE OF ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your last issue (p. 131) Professor Tait says:—"We now *know* that electricity is not a substance," and the statement is emphasized by the italics here reproduced. I am at a loss to imagine whom the "we" can refer to, for I am not aware that any discovery has been made to alter the aspect of the question as to the nature of electricity since Clerk-Maxwell observed that "we do not know whether positive electricity, or negative, or both, should be called a substance or the absence of a substance." It is well known that Faraday declared his inability to offer any opinion on the question. In regard to what used to be termed "the three imponderable elements," it may safely be stated that neither heat nor light is a substance or mode of matter. I grant that we *know* this. But, in regard to electricity, there are many scientific considerations which point to the possibility of its being a kind of matter, imponderable—though perhaps the cause of gravitation—and certainly *sui generis*, but as undestructible and inconvertible as common matter. I have gone further than this conclusion, and have ventured to maintain that electricity is most probably of a material nature. I use the term *electricity* in its original signification of electrical *quantity*, or that which, when a charged conductor is brought into contact with a similar uncharged conductor (the two conductors being under similar conditions), becomes equally divided between the two conductors, without being either diminished or increased. This value (Q)—electricity or electrical quantity—is measured by

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current into time ($C\theta$), or by the ratio of potential difference to electrostatic resistance $\left(\frac{E}{R^i}\right)$. It is not *force* (pressure or pull), because we *know* that electrical force varies as Q^2 or E^2* (for a given surface), and that this value (as well as potential difference and the resistance in the electrostatic circuit) becomes halved when the above-mentioned conductors are brought into contact. Nor is it *energy*, for we *know* that electrical energy varies as Q E, and that this value also becomes halved—the remaining half becoming converted into *heat*—when the conductors are brought into contact, or connected by a conductor which may be supposed to have no charging capacity.

In electrical phenomena force and energy are continually varying, undergoing transformations and conversions. Electricity remains electricity; a coulomb of electricity cannot be converted into anything else, cannot be transformed into any mode of energy. It is as unalterable as a grain mass of hydrogen or aqueous vapour. The variations in the energy of which they are the vehicle cause the electricity, the gas, and the vapour to produce very different effects at different times; but electricity can no more be converted into heat than can a rifle bullet when its motion is arrested. But if electricity be neither force nor energy, and if it be absolutely inconvertible, is it not most probably a kind of matter analogues to which may hereafter be discovered?—Yours, &c.,

DESMOND G. FITZGERALD.

* $\text{Force} = \frac{Q^2}{S} = \frac{E^2}{R^2 S} = \frac{E^2 S}{l^2}$, S being surface and l reduced length of dielectric.

$\text{Energy} = Q\ E = \frac{E^2}{R^i} = \frac{E_i S}{l}$

THE COST OF ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I quite agree with the expression of opinion contained in Mr. Martin's letter in your last issue to the effect that the enormous price of the plant necessary for an installation of electric light is prohibitory to its introduction to mills and factories, where its advantages would tend so much to the comfort and heath of the *employés*. So long as interest and a moderate percentage for depreciation and repairs on plant amount to nearly as much as the price of gas per annum, so long will it be found extremely difficult to induce people to adopt this method of illumination.

Like your correspondent, I have prepared many estimates for electric light installations during the past couple of years, and have been usually met with the objection that the first cost was too great. Why cannot manufacturers offer dynamos at a reasonable price, leaving sufficient margin for profit? and especially why cannot incandescent lamps be sold at a more reduced price than five shillings? Surely the manufacturers of electric light apparatus are standing in their own light by continuing to demand fancy prices. With reasonable charges there would be a larger business, and consequently increased profits, to those engaged in the supply of electrical appliances.—Yours, &c.,

J. ANGELO FAHIE, M.S.T.E. and E.

10, Leinster-street, Dublin,
21st June, 1884.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your correspondent, Mr. Martin, has contributed some very interesting figures to prove that the mere interest and depreciation charges on an electric lighting plant of 520 incandescent lamps will equal the total cost of the gas lighting for a public works using 500 gas jets.

Mr. Martin has, however, omitted to debit the gas lighting with anything but the cost of the gas itself. In all fairness he should have added to it the interest and depreciation of the meter, pipes, and gas fittings fixed throughout the buildings. He should have also pointed out that his estimate for electric lighting plant provides for a light collectively equal to 10,200 candles, whereas the gas plant, on the supposition that one burner equals 12 candles, would collectively equal 6,000 candles. But, after these corrections have been made, the fact still remains that in this case the heavy interest and depreciation charges would so out-weigh the advantages afforded by the electric light that it is extremely unlikely that it will be largely used by Dundee manufacturers.

Your correspondent appears to think that the remedy lies in the cheapening of the electrical apparatus, but I think that your correspondent's figures merely prove that Dundee mill owners use their artificial light for such a small number of hours per annum; namely, taking 500 gas jets, costing £100 per annum, using 5ft. burners, and gas at 2s. 6d. per thousand, equal to using 322 hours only, the conditions are as unfavourable as possible for providing detached installations such as the proposed one.

If such short hours of use of artificial light is the rule in Dundee, it would be interesting to know whether it does not in some degree affect the price of gas itself, as the interest and depreciation charges incident to the manufacture and distribution of gas are annual charges, and having to be divided over a similar number of hours must be proportionately heavy.

The same rule applies to the electric light to a still greater degree, on account of the want of storage. Fortunately, in many towns artificial light is used in workshops and manufactories for very long hours, sometimes amounting to 2,000 hours per annum. In these cases the electric light can be used by the manufacturer himself at an equal, and in some cases even at a lower price, than that of the town gas; therefore, the longer the hours of work the more favourable to the electric light.—Yours, &c.,

R. E. CROMPTON.

London, E.C., June 25th, 1884.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have much pleasure in acceding to the request of your correspondent, Mr. W. C. Martin, that I should give the figures on which my statement was based, that the cost of electric lighting in a mill in which the necessary power can be taken from existing engines is very approximately the same as the cost of gas lighting. I took the general case of a mill requiring a light equivalent to 500 20 candle-power burners, and as the basis of the calculation I assumed (as was fully stated in my lecture) that the lights would be required during 500 hours in the year.

The prime cost was then estimated as follows:—

	£	s.	d.
Dynamo and fittings	£550	0	0
Lamps, 500 at 4s.	100	0	0
Wiring, including holders, cut-outs, switches, and labour	250	0	0
	£900	0	0

As I had no particular case in mind the item for wiring was necessarily little more than a guess. I am glad to find, however, that it agrees well with the corresponding part of the estimate Mr. Martin quotes as having been calculated by him for an actual mill using 500 burners.

For the annual cost we have:—

	£	s.	d.
Interest on £900 at 4½ per cent.	£40	10	0
Depreciation of the dynamo, at 8 per cent. (on £550)	44	0	0
Depreciation of the wiring, at 4 per cent. (on £250)	10	0	0
Renewal of lamps, 250 at 4s.	50	0	0
Coal:—60 h.-p. for 500 hours, requiring 3lb. of coal per h.-p. per hour, with coal at 8s. per ton	16	0	0
Oil and attendance, say	6	0	0
	£166	10	0

Now to get an equal amount of light from Dundee gas we must burn 4 cubic feet per hour in each burner, or $4 \times 500 \times 500 = 1{,}000{,}000$ cubic feet in the year. This, at 3s. 6d. per 1,000 cubic feet costs £175, which the Gas Com-

missioners' discount of 5 per cent. for prompt payment reduces to £166 5s. If my figures are right, gas and electricity, in the circumstances we have here, cost the same.

I do not think that serious exception can be taken to the items given above for the prime and current cost of the electric installation. For the prime cost my figures agree substantially with Mr. Martin's, except as regards the dynamo. He estimates for three machines, and puts their cost at £700. I should prefer a single 500-light machine, not only on the grounds of economy and simplicity, but because it does away with the necessity of high speed driving. For a well-built dynamo running at five or six hundred revolutions per minute, and in the charge of a skilled engine-driver, a depreciation rate of 8 per cent. is surely liberal; and the item for attendance has to cover nothing more than part of the time of a boy who replaces broken lamps.

Mr. Martin tells us that the yearly gas bill of the mill he refers to is only £100. I know the mill in question. It is one which, on account of both its position and its construction, requires exceptionally little artificial light. Besides, there can be little doubt that the 520 lamps in Mr. Martin's estimate would give a total illumination considerably greater than that given by the existing 500 gas burners.

The only important part of my estimate which I can regard with mistrust is the assumption of 500 hours as the time during which artificial light is wanted throughout the year in an average mill. If the actual number of hours is less than 500, the cost of gas will be reduced more than the cost of electricity, since the items for interest and depreciation remain unchanged.

Precise statistics of the number of hours per annum during which gas is burnt in the Dundee mills are not easily obtained, but it appears certain that the number is, in ordinary cases, over 400.

If we assume 400 hours instead of 500, the cost of gas is reduced (by one-fifth of £166 5s.) to £133. The cost of electric lighting is reduced (by one-fifth of £72) to £152. In that case, then, electricity will be somewhat dearer than gas, but the difference is too small to outweigh the many advantages of the new illuminant. And the assumption of no more than 400 hours' use per annum is the least favourable to electricity which, in these northern latitudes, it seems permissible to make.—Yours, &c., J. A. EWING.

University College, Dundee, June 24, 1884.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It would have added considerable value to Mr. Martin's remarks in his letter of this week's issue if he had given the price of gas at Dundee, and the average time of lighting per diem. Taking his figures, 500 gas jets for £100 per annum, obviously gives us the cost of one jet as 4s. a year, or roughly 1d. per week. Supposing the burner is lighted for six hours a day, consuming 5 cubic feet of gas per hour, this would make the price of gas at Dundee at 6½d. 1,000 cubic feet—an altogether incredible figure. Or taking it another way, assuming the price of gas to be 1s. 10d. per 1,000 cubic feet, the gas must be lighted for an average of only two hours a day.—Yours, &c., W. T. GOOLDEN.

2, Victoria Mansions, Westminster,
21st June, 1884.

THE BARROW-IN-FURNESS INSTALLATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the report of an installation of electric light at the Criterion Restaurant, Barrow-in-Furness, published in your issue of 21st inst., you express an opinion that the "Phœnix" dynamo machine is identical with the "Lumley." Kindly allow us to point out to you that you have been misinformed. The machines are not alike either in outward appearance or internal construction. The special point claimed in the "Lumley" patent is that the interior projections of armature plates are provided to carry off the heat generated in armature. These are not found in the "Phœnix." This is one difference between the two machines, and there are many others. We shall be most happy to show you the two machines if you will favour us with a visit to our works, when you can judge for yourself. Trusting that you will find space for this in your next issue.—Yours, &c.,

PATERSON and COOPER.

St. Paul's Telegraph Works, 76, Little Britain,
London, E.C., June 24, 1884.

INCANDESCENT LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In M. Gallice's letter to *L'Electricien*, quoted in this week's *Electrician*, he mentions the appearance of a violet coloured glow in the lower part of the filament in a Gérard incandescent lamp; and speaks of such an appearance as a remarkable phenomenon, inferring that it indicates a better exhaustion of air than is found in other lamps. I do not think that such an appearance as he speaks of is a peculiar characteristic of the Gérard lamp. No doubt many electricians have witnessed this phenomenon with regard to other incandescent lamps. I can say this with some assurance, having seen this effect take place in a Lane-Fox lamp, which was being very severely tested. The lower part of the filament became of a bright violet colour, just as described by M. Gallice.—Yours, &c.,

A. T.

London, W., 20th June, 1884.

THE RISE IN TEMPERATURE OF ELECTRIC LIGHT LEADS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Taking the formula

$$t^0 = \frac{4\rho}{J h \pi^2} \cdot \frac{C^2}{d^3}$$

given in Munro and Jamieson's "Pocket Book," and substituting for the symbols in the left-hand portion of the formula the values given in this work, viz.,

$\rho = 1700$
$J = 4{\cdot}2 \times 10^7$
$h = 2 \times 10^{-4}$ (for bright copper)
and $\pi^2 = 9{\cdot}8696$,

I obtain the following expression:—

$$t^0 = \frac{C^2}{d^3 \times 12{\cdot}192} \text{ in degrees centigrade.}$$

The value d being taken in centimetres, this expression would appear to be altogether erroneous.

Perhaps the authors of the "Pocket Book," or others interested in the question, would kindly point out where the error resides?—Yours, &c., STUDENT.

TAKING OUT THE STAIN OF SULPHURIC ACID.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I would be much obliged if you could let me know through your correspondence column whether there is any way of getting the stain of sulphuric acid out of marble, as a small secondary battery has unfortunately been upset over a marble mantelpiece and stained it very badly.—Yours, &c.,

H. M. T.

CHLORIDE OF SILVER CELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am trying to make a chloride of silver battery, but do not know how to fuse the chloride round the rod of silver. Kindly state in next number of *The Electrician* how to get fused chloride of silver cast on a block of vulcanite which has silver foil rolled round it.—Yours, &c.,

A READER.

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THE ELECTRICIAN.

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All letters intended for insertion in The Electrician, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

We cannot undertake to return drawings or manuscripts, and must therefore request Correspondents to keep copies.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes ... 145
Electro-Chemistry. By Dr. G. Gore. (Continued) ... 150
Incandescent Lighting. By T. H. Seymour Hawker. Illustrated ... 151
Correspondence—
The Nature of Electricity ... 153
The Cost of Electric Lighting 154
The Barrow-in-Furness Installation ... 155
Incandescent Lamps ... 155
The Rise in Temperature of Electric Light Leads ... 155
Chloride of Silver Cells ... 155
Correspondence (continued)—
Taking Out the Stain of Sulphuric Acid ... 155
The Cost of Electric Lighting 156
The Electric Light in Flour Mills. By J. H. Greenhill 157
His Electric Fittings. By Mho 158
City and Guilds of London Institute ... 160
Primary Batteries for Electric Lighting. By I. Probert ... 161
Telegraph Tariffs. By Colonel Webber ... 163
Legal ... 168
Companies' Share List ... 168

THE COST OF ELECTRIC LIGHTING.

Figures, it is often said, may be employed to prove anything—except facts. The use of figures to prove certain foregone conclusions in electric light operations is no exception to this rule. A question frequently asked of late relating to the continued dulness in electric light work is now being partially answered in our "Correspondence" columns. Leaving for the moment this important discussion, let us attempt to put the case as it presents itself to us. The progress of science has introduced a new system of artificial lighting; but another and by no means a bad system of artificial lighting is in the field—in fact, holds possession of the ground. The work of the supporters of the new system is principally that of ousting the old system. Where no artificial light has ever been used, and where the surroundings do not lean to the one system rather than the other little difficulty is encountered in persuading the users to adopt that system which science and common sense pronounce to be best. Under ordinary circumstances, houses, mills, &c., come into the possession of the occupiers with the gas fittings almost or quite complete. A certain amount is paid for fixtures, which amount the householder or proprietor proceeds to forget as soon as paid. It is an incidental tax levied when there is a change of residence. The same remarks that hold in this case will hold whatever the new introduction proposed may be; and not only do they hold in the case of lighting, but in almost all cases of expenditure in ordinary life. Users of steam engines are not generally eager to throw out the engines in use in order to supply their places with other and, it may be, more economical engines. They prefer to wait till the existing apparatus must be replaced, and they replace it by the most modern type in the market. The same will hold good with gas and the electric light. There are times and places when the former must be replaced, and thus comes the chance of electricity. This we contend is the normal condition of affairs, and if no other condition existed, the introduction of anything new would be an almost impossible task. Two most important factors in human affairs are luxury and fashion. Indulgence herein means putting aside the hard and fast commercial considerations, which might otherwise be expected to regulate the human hive. In the case of artificial lighting, as in other things, that which is shown to comply best with the requirements of luxury is indulged in by the luxurious. Fashion follows in the wake of luxury and increases the demand. The increase in the demand leads to increased competition and diminution of first cost, putting the apparatus within the reach of a wider circle of users. We have not considered the case in which the circumstances are altogether in favour of the new introduction, because such cases are few in number and altogether exceptional.

Let us see how the theory agrees with the facts. A few years ago dynamos and lamps cost far more than at present. Manufacturers and patentees are not philanthropists. They work for a profit, and if the demand for their goods is small, a large sum must be added to the prime cost of each machine to make it worth while to make it at all. The increased demand leads to putting down new machinery, diminishing the prime cost, increasing the output, and lessening the price to the consumer. Lamps which a few years ago cost a pound a piece can now be bought for less than five shillings each, and we fancy the cost of dynamos is less than half what it was say at the time of the Paris Exhibition. It is quite evident that the manufacture of electrical apparatus is not the lucrative business that we are led by many to suppose; at any rate, the commercial standing of the companies is not altogether in favour of the lucrative view. Having thus briefly viewed the question from the manufacturer's standpoint, we will now discuss the interesting letters in our "Correspondence" columns. Comparisons are, we know, odious, and especially is it so between gas and electricity. If in such a comparison we keep entirely to figures, the result is very misleading, because electricity presents so many advantages that cannot then be brought into the comparison. It has become customary, however, to make such comparisons, and hence we may take them for what they are worth. The cost of gas per annum is not stated upon the gas bill. To the bare amount paid to the gas company must be added depreciation and interest upon fittings, depreciation upon decoration, and so on. If we have to consider an entirely new installation of gas or of electricity, we are prepared to submit that the cost of the fittings in the house and the cost of conduction from the point of generation to the point of usage are not more in the case of electricity than in the case of gas. Will any one be bold enough to say that the cost of a central electric light station is more than the cost of a central gas station? This brings us to the question of burning coal to produce electricity as against the burning of

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coal to produce gas, and after all we maintain this is the crucial point.

An isolated installation is hardly a fair test of cost in any case. Mr. Crompton and Professor Ewing point out that the time during which the artificial light is required is a most important factor in the result. It matters little to a gas company whether 500 burners are in use 500 or 300 hours during the year. The average consumption of gas over the whole district is the standard by which their actions are guided. In the case of separate installations, however, whether of gas or of electricity, of 500 burners, the number of hours is of the greatest importance. A question raised by Professor Ewing needs elucidation, and a good deal of information might easily be given. What is the percentage of renewals of lamps? Fifty per cent. per annum seems enormous. Is this estimate founded upon practical work? We have again and again asked users as to the loss of lamps, but have always understood that the percentage of renewals was far below the estimate given by Professor Ewing when the number of hours of burning during the year do not exceed five or six hundred.

THE ELECTRIC LIGHT IN FLOUR MILLS.*

BY J. H. GREENHILL, OF BELFAST.

After explaining the difference between the electricity produced by friction machines and that produced by batteries, Mr. Greenhill proceeded to explain the construction of a battery and dynamo, interpolating a considerable amount of elementary matter for the benefit of his audience, with which we need not trouble our readers, though doubtless it was well appreciated at Stockton. In speaking of dynamos, Mr. Greenhill said :—I have constructed a machine specially for this meeting, which is the first of its kind, and I hope will do credit to its maker. It consists of magnets made up of an immense number of thin sheets of charcoal iron; upon these are placed coils of fine insulated copper wire, of which there is over half a mile. The rotating armature is joined to plates of brass termed a "commutator," from which the electricity is collected by brushes or strips of copper. The armature is driven by a belt from a large fly-wheel operated by means of two winch handles. This little machine is capable of supplying current for eight lamps of 20 candles each, or one small arc lamp; however, as we only can apply the power of two or three men, the utmost they can turn will supply currrent for five lamps of 20 candle-power each, as it requires slightly more than half of a horse-power (indicated) for this number, and even with these the men are not able to maintain the speed to keep the lamps to their full brilliancy. The incandescent lamps here exhibited are Swan's, Woodhouse and Rawson's, and Burnstein's. Having described the principles of arc and incandescent lighting, Mr. Greenhill said a few words on the storage of electrical energy, and then proceeded to give some details as to the cost of lighting mills, which we think will be of considerable interest to our readers at the present moment. He said :—With reference to the relative merits of the electric light compared to other means of artificial illumination, the main question is How does it compare with gas in cost? To answer this, various considerations have to be taken into account. First—What is the price of gas and its illuminating power? Further, what means are there for driving the electric light machine? Well, to arrive at perfectly unbiassed opinions, let us take gas at 2s. 6d. per 1,000ft. and of 17 candles illuminating power, and we will suppose the comparison has to be made as to relative cost in a flour mill with 100 lights of 20 candle-power each, or an aggregate light of 2,000 candles. To obtain this light by gas it will take 590ft. per hour, and to this must be added leakage during the day, or if the gas is turned off, the refilling of the pipes, which I think may be taken at 1 per cent., or say in round numbers 595ft. of gas per hour.

	s.	d.
Cost of which at 2s. 6d. per 1,000ft. =	1	5¾
Cost of repairs to pipes and renewal of burners £6 per annum = ¾d. per hour (2,000 hours)	0	0¾
Attendance 5s. per week = £13 per annum = 1½d. per hour	0	1½
Interest on first cost, say £50 at 5 per cent. = £2 10s.	0	0¼
Cost of gas per hour	1	8¼

Or for 2,000 hours £168 15s.

Electric light—100 lights of 20 candle-power each = 2,000 candles—

	s.	d.
Power required, say 11 indicated horse-power at 3lb. of coal = 33lb. at 10s. per ton	0	1¾
Renewal of lamps, taking average durability at 1,500 hours represents 1 lamp for every 15 hours to be renewed, costing 5s. = cost per hour	0	4
Attendance 5s. per week = £13 per annum = 1½d. per hour	0	1½
Oil and waste 3s. 6d	0	1
Interest on first cost, say £300 at 5 per cent. = £15. per annum	0	2
Repairs of machine, &c., and depreciation 5 per cent. on £130 = £6 10s	0	0¾
Cost of electric light per hour	0	11

or for 2,000 hours £91 13s. 4d., thus showing an annual saving over gas of £77 1s. 8d.

Now, lest it should be considered that this is too favourable an estimate for the electric light, I have obtained from Messrs. Furlong and Sons, of Lappsquay Mills, Cork, who were the first to permanently adopt electricity in Ireland, the result of their experience. The gas in Cork is 3s. 11d. per 1,000ft., and therefore it is considerably in favour of the electric light; but it will be observed that the saving is so great that, even if gas had been as low as 2s. 6d., the results would entirely have borne out my calculations. Messrs. Furlong's installation consists of 50 lights equal to 20 candles each, or just one half what I took as a basis for our calculations. Their gas bill was as follows :—

	£	s.	d.
In the year 1877	161	0	6
,, 1878	192	3	1
,, 1879	136	6	7
,, 1880	142	8	5
,, 1881	114	17	11

The illuminating power of the gas is 18 candles. It will be observed there was a great falling off in the cost between the years 1878 and 1879, arising from alterations in their gas arrangements, and the adoption of a gas regulator. The electric light was put in at the end of 1881, with the following result:

	£	s.	d.
Renewing lamps per annum	19	15	0
Repairing an accident to machine	7	0	0
Renewing brushes	1	5	0
Oil and waste	1	0	0
	£29	0	0
Paid for gas while mill was idle	12	10	0
	£41	10	0

Nothing was put down for interest and coals; but personally I am able to calculate these pretty clearly, and they amount to £20 8s., which added to £41 10s. = £61 18s.

Messrs. Furlong have not calculated the renewal of gas appliances, nor have they added cost of attendance in either case. Hence the saving to them has been considerably over £60 per annum. They run the machine now day and night.

I have also received reports from Messrs. Hall and Co., of Cork, who have used the electric light in their mills for about two and half years, in which they state that they now save about 70 per cent. of their original cost of gas; further, that the electric light has given complete satisfaction. However, in their report they do not estimate anything for power, as they consider it so trivial as not to be noticeable on their engine, but they add that they consider the electric light is an incalculable advantage to flour millers considering it minimises the risk of fire, and reduces the temperature of the mill very much. Messrs. Furlong and Sons, of Fermoy, have also written to me most favourably of the electric light, which they have had in

* Abstract of a paper read before the National Association of British and Irish Millers, at the Millers' Convention, at Stockton-on-Tees, 24th, 25th, and 26th June, 1884.

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operation for about fifteen months, and the saving in their case compared to gas has been very great. They also report many of the lamps originally put up still in perfect condition after having worked 3,756 hours.

It will be observed that I took an average of 1,500 hours as the durability of the lamps; some would not last so long, while others would, and have far exceeded this period, and as the renewals of the lamps appear in my calculations the heaviest item, it follows that if they last longer, or become cheaper in cost, which we may reasonably expect, the expense for electric light in flour mills will be still further reduced.

There are many firms of flour millers now using the electric light throughout the country of whom I have not heard, but I have been favoured by Mr. Wilson Hartnell, of Park-row, Leeds, who is the agent in Yorkshire for Messrs. R. E. Crompton and Co., with the following list of installations erected by him, under the superintendence of Mr. Farrar:—

Messrs.	Reynolds and Haslegrave, Wakefield	50 lights
,,	Robinson and Hanley, Doncaster	50 ,,
,,	W. and J. Bairstow, Keighley	62 ,,

The following is a list of the installations which I have erected in flour mills in Ireland.

Messrs.	Furlong and Sons, Cork	50 lights.
,,	Hall and Co., Cork	50 ,,
,,	Furlong and Sons, Fermoy	64 ,,
,,	A. R. Walker, Newry	62 ,,
,,	D. and W. Carmichael, Belfast	64 ,,
,,	Bannatyne and Sons, Limerick	120 ,,

In conclusion, I have only to direct attention to the safety of electricity from fire with properly erected installations, compared to gas. Personally, I do not consider there is one-fourth the risk of fire from the electric light; matches and naked lights are not required, and besides these points, the air remains perfectly pure in the mill, thus adding to the health and activity of the workmen. With respect to danger to life by using electricity, there is practically no danger whatever in using direct current machines of low tension, such as are employed for incandescent lighting, nor is there much, if any, danger with arc light machines, presuming that it is not required to have too many arc lights driven off one machine.

HIS ELECTRIC FITTINGS.

BY MHO.

About four o'clock on a Wednesday afternoon of December, 1883, Mr. William Lightearnest was plodding his way along the West Strand, when he accidentally met, face to face, an old college chum of his, named John Doughty Thump.

"Well, upon my word, Thump, you were about the last man whose path I dreamt to cross at this precious moment. Whatever have you been doing with yourself during the year?"

"The question, my dear boy, is somewhat of a puzzle. Have been for a climb over the Alps, then for a walking tour through Brittany; and lastly to Madrid for the bull-fight season, whence I returned out of humour with myself and the world, fully determined to kill the rest of the year in riding, shooting, lawn tennis, and other health-giving and lawful pursuits. In this converted temper I followed the crowd to the Fisheries Exhibition, but failed to distinguish you in that wonderful collection. Still, presume you went there with the sum-totum of civilised peoples."

"Yes, several times, always finding it full of scientific interest. The ship models were very fine, and the fishing tackle, especially the delicate meshing in the Norwegian Court, splendid. Then, again, the vast number of curiosities related far and near to the fishing industry were extremely rare."

"Decidedly rare," echoed Thump; "and, to tell you the truth, I was more interested in the Fisheries than I am usually in such scientific displays, which, as you know, generally bore me to death. The constant staring inflames my eyes, the kaleidoscope of objects worries my brain, and the slow locomotion invariably gives me a wretched ache in the spine. But there was much at the Fisheries to compensate for all this martyrdom. There was that old craft of Grace Darling's, reminding one so forcibly of womanly pluck, and teaching us that men have no monopoly of the quality. Another thing which took my fancy was that Irish cockle-shell thing, comparable only to a wrecked and dissolved Christmas hamper But there, with my habitual selfishness, I am dilating upon my own doings and forgetting all about your sport. Come, what has kept *you* secluded for the whole year?"

"Unconsciously imitating your example, I have been on the Continent, visiting the exhibitions at Amsterdam, Munich, and Vienna."

"On some scientific hobby, I infer?"

"Yes, in search of the best forms of electric fittings."

"So you are bent upon fitting up your place of business with the new-fangled light."

"No, my private residence down at Chudleigh. *En passant* if you can run down next Monday afternoon I shall have much pleasure in showing you over the old place under a new light."

"Most willingly, my good friend, but first let me see if that fits in with my other engagements. To-morrow (Thursday) I go out practising with my volunteer corps; Friday I hope to run down and have a look at that Weston fellow on his long walk; Saturday I trundle over my customary thirty miles on my bicycle; Sunday, well I will not divulge what I ought to do on that day; but on Monday afternoon I will most certainly visit Chudleigh, and inspect your electric fittings."

"Thank you, and therefore agreed. My brougham and I will be in attendance on the four o'clock train, so for the present, *Auf wiedersehen, mein freund!*"

"A good bargain, so till we meet at Chudleigh, good bye!"

The above dialogue affords ample evidence that William Lightearnest and John Doughty Thump had cultivated decidedly opposite tastes; still, as often happens, they had become, in spite or more truly perhaps because of their dissimilarity of temper, very intimate friends.

Lightearnest was of a studious and scientific turn, a little pedantic in his ways, and fond, as you perceive, of spicing his conversation with quotations from other languages. John Doughty Thump was a full-blown, large-minded specimen of muscular christianity, whose style of conversation sufficiently betrays his character, and therefore relieves us of the onerous duty of describing his salient points.

The appointed Monday came, and as arranged Thump took his departure by the afternoon train for Chudleigh, where on arrival he entered his friend's brougham, and was immediately carried in the direction of Chudleigh House—a fine model of a suburban residence, surrounded by extensive acres of its own, and approached by a long straight drive, lined on each side by towering elms, which extending their huge arms in mutual embraces formed a green canopy between the road and heaven. A lodge stood at the opening of this avenue, and over the gateway was suspended a monster arc lamp, shedding its bright lustre over hedge and pasture, and clothing the vicinity in a soft moony glow.

As the brougham shot under this brilliant circle of light, Thump looked enquiringly into his friend's face, as if he would ask what all the illumination meant. But Lightearnest at once broke the spell.

"Do not perplex your mind, my dear good fellow, it's only the light of the arc lamp over the lodge gate."

"But what are all those illuminated hour-glasses on each side of the way?"

"Why, they are incandescence lamps, my dear friend. You must have seen lots of them at the Fisheries."

"Now you mention it, I remember I did. But I say, this electric light business must cost you a nice penny."

"Not at all, I find it quite as economical as gas, and for equal cost the light is three to five times as powerful."

"Is that really a fact? By the way, what kind of a light is this in the carriage, just above our heads?"

"If you turn you will see it is one of your little hour-glasses."

"Impossible! There is nothing to show how the light is produced. You don't mean to say it burns like a tallow candle?"

"I will explain it to you if I can. First we pass a current of electricity through the carbon filament, which under this

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influence gradually becomes incandescent, with an illuminating power equal to twenty of your tallow candles, or, if you prefer the definition in terms of horseflesh, each lamp represents one-eighth the estimated strength of a horse.

"Yes, but where do you get the electricity from? I see no machinery about."

"No, you are sitting on it."

"On what?" And poor Thump involuntarily stood up and looked expectantly down upon the smooth carriage cushion.

"Oh pray sit down, my dear old boy, I only meant to tell you that the accumulator, or charged battery, is contained within the box under your seat. You needn't be alarmed; there is no danger of you receiving any violent shock to your system. Altogether there are three incandescent lamps to the brougham, one as you see inside and two side lights out."

At that instant the brougham drew up at the hall, and Thump, bent upon being polite, rose to open the carriage door.

"Allow me, my dear fellow," said Lightearnest.

"Pardon me, I would rather——"

"But be patient for one moment, and please keep your seat. Now, be kind enough to press that button facing you."

"Thump mechanically pressed the button, and the carriage door flew wide open."

However do you manage that?" exclaimed Thump.

"Oh, it's all done with the help of the accumulator, an electro-magnet, and a small iron armature, which, on pressing the button and setting the current going, is attracted by the poles of the magnet."

"But I see no current, nor magnet, nor furniture. What did you say the last thing was?"

"Do you see the handle of the door?"

"Yes."

"Well, that is the electro-magnet, and the armature is hidden out of sight near what looks like the keyhole of the door."

The two friends had by this time reached the hall door.

"I dare presume you will allow me to ring?" said Thump.

"Not the slightest necessity for that antiquated practice. Will you kindly press that button on your right?"

Thump obeyed, and the door opened as of its own accord.

"But I say, Lightearnest, what marvellous things these buttons of yours must be!"

Lightearnest laughed, and patronisingly patted his friend on the back.

Thump paused awhile on the door mat, mechanically rubbing the dirt off his boots, but his host assured him that this time-honoured and cleanly custom was quite out of fashion at Chudleigh.

"Just plant one of your feet on the mat."

Thump did so, and the mat at once began a to-and-fro movement across the floor, cleaning Thump's boot in a most masterly and shoeblack-like style.

"Now the other foot."

Thump silently acquiesced, and then looked down on both boots to find them spotlessly clean.

"I call that a most wonderful piece of trickery, and I should be happy to patronise the principle if I only understood the knack of it."

"Oh, you shall understand it all by and by. Meanwhile, content yourself with the reflection that the old-fashioned proceeding of 'rubbing one's shoes on the door mat' has seen its day, and here at least is considered to be a thing of the past. In future we are determined that the mat shall honour the shoe, just as the discovery of Galileo forced our pigmy earth to take a diurnal plunge in the light of the sun, forbidding this dignified luminary ever again to sweep out gigantic circles about our insignificant centre."

Lightearnest then led his friend to the smoking room, the door of which, as usual, flew open under the magic pressure of the thumb. The apartment was duskily lit up by a series of what the neo-scientific Thump characteristically termed "red marks." But as soon as his host turned a small switch standing on the table these "red marks" gradually changed into brilliantly white incandescent streaks of light. Thump, thunderstruck, mumbled to himself something inaudible about the colours of the setting and the splendour of the noonday sun.

"Allow me to offer you a cigar."

"Thanks, old boy. Now please give me a light, and if not inconvenient a new-fangled one."

Thump gave a farewell chuckle to this request, thinking that he had at length "set a poser."

"As you wish it so much I will try to arrange one for you," and Lightearnest drew forth a small tin match box, which he held close under Thump's eyes, asking him to look at it attentively. As Thump gazed at this contrivance there gradually arose before his astonished vision a coil of "dull red marks," which in turn became metamorphosed into a brilliant fold of light.

"There, my good friend, you can now tip the end of your weed with pure Promethean fire."

It need not be said that by this time poor Thump's mind was in a state of wild bewilderment. Sinking into an arm chair, he besought Lightearnest "just to let him into the particular go of this button business."

"Moreover, I should be extremely obliged to you if you would explain away a little of the mystery of all these puzzling phenomena, sedulously avoiding big words, scientific jaw-breakers, and those foreign tit-bits of yours, which will only bamboozle my mind the more."

"The task you set me is not so easy as it looks. But I may tell you that the amusing electric effects which you have so far seen are all due to one great physical fact, namely, that if you pass a current of electricity through a coiled magnet, and at the same instant place a piece of iron called an armature in front of the poles of the magnet, the latter will draw the armature towards itself, and hold it fast. As a boy you must have often played with a red magnet and a needle. Well, a coiled magnet under the influence of an electric current attracts the iron and lets it go again in precisely the same fashion. Now this current is set in motion or cut off by pressing or releasing the button. Imagine, then, the latch of the carriage door to be the needle or armature, and you will understand how the attractive power of the handle-magnet helps to withdraw the latch and open the door. In a similar way the to-and-fro motion of the door-mat was brought about by the making and breaking of contact of an electric circuit, which produced a corresponding reciprocating movement in an armature working in a rectangular hole or slot and attached to the under surface of the gutta-percha matting. This reciprocating motion of the mat is beautifully expressed in French as *un mouvement de va-et-vient*; in German by *eine hin und her bewegung*; and in Spanish by ——.

"Thank you very much," interrupted Thump; "the new light was just beginning to dawn upon me. So all this is derived from the red magnet and needle business. The times I have made that old red horseshoe run off with poor grandfather's steel nibs and mother's darning needles!"

"I'm glad I've made the matter so clear to your mind. Circular motion is obtained in a similar way. You have only to remember that if the poles of a magnet be opposite, or in other words, one north and the other south, they will attract each other; whereas if they be alike—that is, both north or both south—they will mutually repel each other. Hence, if you have a round armature enclosed between a number of alternately north and south poles, it follows that once the armature is started it will continue to revolve, because any part of it is constantly being repelled by one and attracted by the other pole.

"That's all done on the peg-top principle, I suppose," suggested Thump.

"No, not at all."

"Well, be that as it may, I remember that when we used to play at that juvenile game it was necessary to have a 'coil' of string and an iron spike, which I would modestly venture to match against your coiled magnet and iron armature."

"But, my dear good boy, peg-top velocity is due to a mechanically applied force, tangenial to the conoidal surface of the top; whereas the revolution of an armature depends upon the principle of alternate attraction and repulsion."

Thump stretched his long legs, protested against the attempt to floor him by big words, and gave expression to the gravest

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fears that some kind of circular motion was at that moment going on within his own brain.

"Then perhaps you might find relief in a stroll round the garden."

The two friends at once rose and sauntered down the paths of the large garden. The subject of electricity gave place to more ordinary topics of conversation. Reminiscences of college days were exhumed and re-discussed with all the vehemence and enthusiasm of youth. Suddenly, however, Thump's attention was arrested by a draw-windlass over a well, which stood at the end of one of the walks. "By Jove, Lightearnest, the axle of that winch is turning round without the aid of man, or other agency."

"Yes, I see it is," said Lightearnest, but you know the old Latin philosopher insists upon it—'*Ex nihil fit nihil.*'"

"Then, may I ask, where the deuce is the man at the wheel?"

"He stands by your side."

"What you?"

"Yes."

Thump's thoughts reverted to the magic buttons, and after a minute search he discovered that a kind of lever was concealed, and being pressed under his friend's right foot.

"There, in that winch," said Lightearnest, "you have an example of circular motion produced by the action of an electric current."

Thump stared mutely at the contrivance, saw it lift and tip a bucket of water, and then solemnly adjudged it to be "quite a marvellous piece of mechanism"—after which scientific outburst the two friends returned to the house in obedience to the fingers of the tower magnetic clock, which marked the dinner hour.

Dinner over, Lightearnest invited his friend to a game of billiards, in which the marking was done by pressing any one of a series of buttons fitted into the flat edge of the table frame. Thump expressed no surprise at this clever adaptation, for he was now prepared to regard buttons as containing the latent solution of every conceivable problem. Therefore he applied his thumb with all the well-poised complacency of a *connoisseur*, declaring that he considered the new button a vast improvement upon the old finger-marker.

But now a cursory glance at his watch warned our guest that it was growing late. He had barely time left to catch his last train; so rushing down into the hall, he hurriedly cast on his overcoat and seized hold of his hat, which he discovered required a little trimming up.

"Could you, Lightearnest, as a last favour, oblige me with a hat brush?"

"Certainly, will you kindly insert your hat into that hollow cylinder thing?"

Thump obeyed, and the hollow brush began at once a series of revolutions, bringing out upon the hat a gloss which, enhanced by the reflected light of the arc lamp in the hall, fairly dazzled the wondering eyes of our departing friend.

"Well, I am loth to leave you and your fairy mansion, but it is so fated; good-by, and many thanks for the amusement your new fittings have afforded me."

"*Adios, amigo mio! Omne tulit punctum qui miscuit utile dulci.*"

John Doughty Thump then entered his friend's brougham, and was wheeled off to catch his train, vowing as he went that it would be a long time ere he forgot his marvellous experiences at Chudleigh House.

CURIOUS ACCIDENT BY LIGHTNING.—During a storm at Greenville, Rhode Island, U.S., on the 9th May, says an American paper, the lightning ran by the telephone wire to the Windsor Mill, where there is no telephone, but the wire is disconnected just outside the building. The lightning was led by the wire to the corner of the mule and weaving rooms, and entered the building under the jet. It followed the water pipe and set the sprinklers going, and at the same time fired the stock in the mules. By this singular provision of an active extinguishing agent at the moment the fire started serious loss was prevented, as the fire was soon drowned out.

CITY AND GUILDS OF LONDON INSTITUTE.

The following questions were set at the recent examinations:—

PAPER 22 B.—*Electric Lighting and Transmission of Power.*

ORDINARY GRADE.

[*Candidates are not to answer more than two out of the first three questions, and not more than seven questions altogether.*]

1. What is the difference between the electromotive force of a battery and the potential difference maintained at its terminals? Explain how it is that when a generator of electricity is employed to send currents through a number of parallel circuits, the current passing through any one of these circuits is practically independent of the currents passing through the remainder, if the resistance of the generator is small compared with that of the circuits.

2. Explain fully what is meant by saying that a body has a large electric capacity. The tendency of an electrified body to lose its charge can be increased by attaching a metallic point to it. Does this alter the capacity of the body? Give your reasons for your answer. What exactly do you understand by the statement that the joint resistance of two parallel wires is equal to the product of their resistances divided by their sum? Define an ohm, ampere, volt, coulomb, and farad.

3. How does the electricity produced by an electric machine differ from that produced by a battery, and how can a battery be made to produce the same results as an electric machine?

4. Thirty accumulators, each having an electromotive force of 2·1 volts and a resistance of 0·002 ohm are employed to feed incandescent lamps. If the lamps require 45 volts and 1·25 ampere each, what is the maximum number of lamps that can be employed?

5. What is meant by the characteristic curve of an electric generator? Draw the characteristic curve for a battery, a series dynamo, a separately excited dynamo, and for a shunt dynamo.

6. The speed of a dynamo is kept constant while the external resistance is gradually diminished. Explain how the electromotive force, and how the potential difference at the terminals vary:—1st, when a series dynamo; 2nd, when a shunt dynamo is employed.

7. Explain how it is that when a gas engine is used to work a *shunt* dynamo to charge accumulators the gas engine may be started by the current from the accumulators working the dynamo as a motor, and so that when the gas engine has got up speed the dynamo will now charge the accumulators; and show why this cannot be done with an ordinary series dynamo.

8. When lamps are fed in the ordinary method in parallel circuit, show how to calculate the falling off in potential difference as we proceed along the mains. Describe a method of arranging the mains so that the potential difference maintained between the terminals of a number of lamps in parallel may be the same throughout the whole circuit, and show how the gauges of wire that must be employed for the various portions of the main conductors may be calculated.

9. A room containing 60 lamps, each requiring 80 volts, is at a distance of 200 yards from the dynamo; what must be the diameter of the copper of the main leads so that the potential difference at the lamps is not less than the potential difference at the terminals of the dynamo by more than 1 per cent.—1st, when the lamps require 45 volts; 2nd, when they require 110 volts? One yard of commercial copper wire one square inch in section has 0·00002435 ohm resistance.

10. How can the direction of rotation of an electro-motor be reversed—1st, if it be a magneto motor; 2nd, a series motor; 3rd, a shunt motor? Give a drawing of a good speed-reducing gear to be used when a motor is required to drive slow-moving machinery.

11. Describe in detail the construction and use of a photometer suitable to be used with an incandescent light and a photometer for an arc light. What variation occurs in the

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illuminating power—1st, of an incandescent light; 2nd, of an arc light when viewed through red and through green glass? How does the intensity vary for beams at different angles in the same vertical plane for arc lights and for incandescent lights—1st, when a continuous current; 2nd, when a reverse current is employed?

12. What is meant by the "lead" in the brushes of a dynamo and a motor? Show exactly when it is necessary to alter the lead for a series dynamo and for a shunt dynamo. Apply your answer to question 7, and consider whether the lead should be the same for the shunt dynamo when running as a motor and when subsequently charging accumulators.

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22 C.—*Electrical Instrument Making.*

ORDINARY GRADE.

[*Candidates are not to answer more than two out of the first three questions, and not more than seven altogether.*]

Questions 1, 2, and 3 are the same as in the preceding paper, 22 B.

4. The deflection of the needle of a galvanometer is not as a rule proportional to the strength of the current. Describe in detail various methods of ascertaining experimentally the connection between different currents, and the deflections they respectively produce. Show clearly what is the least amount of apparatus you must employ for carrying out each method. In what way would it be best for a galvanometer maker to record, for the benefit of the purchaser, the law connecting deflection with current?

5. Give a drawing, with detailed description, showing the construction of a dead beat galvanometer, and of a galvanometer the readings on which are not affected by external magnetic charges. Describe generally the various ways in which a galvanometer can be made so that the deflections shall be directly proportional to the current.

6. How would you make a cheap resistance, the magnitude of which could be altered at will, to be used for strong currents? Give a drawing of the details, and a specification for the guidance of the maker.

7. A bobbin measuring 2in. between the end cheeks, and having an internal and external diameter respectively of ½ and 1½in., has to be wound. What length of wire, the diameter of which, including its insulating covering, is 0·012 of an inch, would be required to fill the bobbin?

8. A potential difference of 50 volts maintained at the terminals of a galvanometer wound with a resistance of 1,000 ohms produces a deflection of 45°. If the existing coil be replaced by another of exactly the same size and shape, what must be its resistance so that a potential difference of 120 volts may produce the same deflection with the same controlling magnetic field? Compare the heating of the bobbin in the two cases if the deflection of 45° be maintained for a considerable time.

9. Give a drawing of a charge and discharge key having high insulation, and write a specification such as should accompany your drawing if you were ordering such a key to be made.

10. What brand of steel is the best to be used for making permanent magnets? Describe *fully* how the steel should be hardened, and how magnetised, so as to produce—first, a very powerful magnet; secondly, a magnet whose strength would alter very little by time. In what way would the size of the magnet to be made modify your answer?

11. Describe fully the best method of joining together two thick pieces of gutta percha covered cable, so as to ensure good conductivity of the conductor, and good insulation of the gutta percha at the joint.

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PRIMARY BATTERIES FOR ELECTRIC LIGHTING.*

BY ISAAC PROBERT.

It has been said that "history repeats itself," and this quotation was never more appropriate than to the subject that will engage our attention this evening.

All of us probably know that it was by a primary battery that the electric light was first produced. So far back as 1802 Sir Humphrey Davy, using a battery consisting of plates of copper and zinc dipping into dilute acid, obtained the electric arc between poles of carbon. In the *Journal of the Royal Institution* for that year, Davy, in describing some experiments on the spark yielded by the newly-invented galvanic battery, uses these words:—"When, instead of the metals, pieces of well-burned charcoal were employed, the spark was still larger, and of a vivid whiteness." He also pictures an apparatus for, as he says, "taking the galvano-electrical spark in fluids and aëriform substances." It consisted of a glass tube open at the top, and having a tubular outlet at the side through which a wire tipped with charcoal was introduced, another wire, also tipped with charcoal, being cemented in a vertical position through the bottom.

In the same year the electric light, sustained by voltaic action, was publicly shown in Paris by the citizen Robertson. Professor Sylvanus P. Thompson, in an interesting communication to *Nature*, has quoted a passage in the *Paris Journal* of March, 1802, from which it appears that the experimenter used a voltaic pile of 120 elements of zinc and silver, to each pole of which he attached a carbon. On bringing the carbons into contact a brilliant spark was obtained of extreme whiteness.

A few years later, Davy, with the large battery of 2,000 cells, which the munificence of some members of the Royal Institution had placed at his disposal, obtained an electric light of a power that has rarely been surpassed, even in our own day.

Thanks to the kind efforts of our chairman, one of Davy's original battery cells is on the table to-night. The complete battery, to use Davy's own words, consisted "of 200 instruments connected together in regular order, each composed of ten double plates arranged in cells of porcelain and containing in each plate 32 square inches. The battery, when the cells were filled with 60 parts of water, mixed with one part of nitric acid, and one part of sulphuric acid, afforded a series of brilliant and impressive effects. When pieces of charcoal about an inch long and one-sixth of an inch in diameter were brought near each other (within the thirtieth or fortieth part of an inch), a bright spark was produced, and more than half the volume of the charcoal became ignited to whiteness, and by withdrawing the points from each other a constant discharge took place through the heated air in a space equal to at least four inches, producing a most brilliant ascending arch of light, broad and conical in form in the middle."

The electrician, Children, constructed a battery of twenty cells, having huge double plates four feet by two, of which the whole surfaces were exposed, in a wooden trough, in cells covered with cement, to the action of diluted acids. It was the grandest combination ever then constructed for exhibiting the effects of extensive surface. To quote Davy's words:—"Points of charcoal ignited by it produced a light so vivid, that even the sunshine, compared with it, appeared feeble."

The light obtained by these experimenters was beautiful in the extreme, and naturally excited the admiration and the hopes of the public, or at least of that educated section of the public to whom the advances of science are not unknown; but it was in no way a practical light. The copper-zinc battery used in the experiments was crude, and quite incapable of sustaining a constant current, the carbon points employed for the arc to play between were mere sticks of wood charcoal, which gave an unsteady light and rapidly consumed, and the beautiful regulators with which we are familiar, for keeping the length of the arc constant, were then quite unknown.

It has just been said that the current obtained by the battery employed in those early experiments was not constant. This want of constancy is due to what is called the polarisation of

* Paper read before the Society of Arts, May 28, 1884.

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the battery—that is, the deposition of hydrogen gas upon the copper plate. In the working of the battery, the zinc plate is oxidised and transformed into sulphate of zinc by the sulphuric acid in which the plates are immersed. At the same time, hydrogen gas is liberated on the surface of the copper plate, where it collects and forms a layer of appreciable thickness, which offers considerable resistance to the transmission of the electric current. It also gives rise to an electromotive force opposed in direction to that of the copper-zinc couple. The effect of the polarisation of the battery is, then, to considerably reduce the current flowing, and worse than this, any amount of deposited gas varies with time and other circumstances, and the current likewise varies. Such a battery, when used to produce the electric light, furnishes a light of constantly varying intensity, which is extremely painful to use, and possesses other drawbacks also.

It is evident, then, that a battery, to be of any use for practical electric lighting, must be capable of generating a constant current. It should also possess these other qualifications, viz., a high and constant electromotive force and a small and constant internal resistance. It should consume inexpensive materials, and should consume nothing when it is producing no current. It should be capable of being easily cleansed, and of being supplied with fresh materials. It should require no skilled attendance. Unfortunately, no battery hitherto invented possesses all the required qualifications.

So long as constant batteries were unknown, the electric light remained a scientific curiosity, but the invention by Grove, in 1836, of his nitric acid battery gave a fresh impetus to the subject. Of all the points enumerated, the power to furnish a constant current is the most important. As the want of constancy of a battery is due very largely, although not exclusively, to the deposition of hydrogen gas upon the copper plate, inventors naturally turned their attention to the devising of methods of ridding the battery of this objectionable feature. Mr. Alfred Smee was very early in the field; he found that by roughening the copper plate the disengagement of the bubbles of hydrogen from its surface was greatly facilitated. The gas, instead of forming a smooth layer upon the copper, collected upon the rough portions, and was discharged upwards through the liquid in streams.

On further investigating the subject, Smee found that it was not necessary that these roughenings of the surface should have appreciable size. In fact better results were obtained with a multitude of small points, from which the gas could be disengaged as quickly as it was liberated by the electrolytic action of the battery, than with a few points of large size, which, although capable of releasing big bubbles, yet permitted the gas to remain on the plate until the big bubbles had been formed by the aggregation of the tiny particles of gas which first appear. He therefore abandoned the copper plate, roughened mechanically, with which his earlier experiments were performed, in favour of a platinum plate, coated with a deposit of very finely divided platinum, obtained by exposing the plate to the action of solution of chloride of the metal, under the influence of the galvanic current. In our own day, platinised silver is often, through a false idea of economy, substituted for the platinised platinum.

This was a very great advance. The Smee battery was justly esteemed at the time for its great constancy as compared with the batteries previously in use. But its constancy, although great in comparison with that of the other batteries then known, was still very far from perfect.

Smee's method of eliminating the ill effects of the layer of hydrogen was but a method of removal, and the question naturally presented itself to the minds of inventors whether a method of prevention could not be devised. An answer in the affirmative was given by Professor J. F. Daniell, of King's College, who invented a battery which remains to this day unequalled in constancy. You may be interested to hear the description of this first constant battery worthy of the name, in its first form, in the inventor's own words. They are these:—

"A cell of this battery consists of a cylinder of copper three and a-half inches in diameter, which experience has proved to afford the most advantageous distance between the generating (that is the zinc) and conducting (that is the copper) surfaces, but which may vary in height according to the power which it is wished to obtain. A membranous tube, formed of the gullet of an ox, is hung in the centre by a collar and circular copper plate, resting upon a rim placed near the top of the cylinder, and in this is suspended, by a wooden cross bar, a cylindrical rod of amalgamated zinc, half an inch in diameter. The cell is charged with a mixture of eight parts of water and one of oil of vitriol, which has been saturated with sulphate of copper; and portions of the solid salt are placed upon the upper copper plate, which is perforated like a colander, for the purpose of keeping the solution always in a state of saturation. The internal tube is filled with the same acid mixture without the copper. A tube of porous earthenware may be substituted for the membrane with some little loss of power. A number of such cells admit of being connected together very readily into a compound circuit, and will sustain a perfectly equal and steady current for many hours together, with a power far beyond that which can be produced by any other arrangement of a similar quantity of the same metals.

"The surface of the conducting metal is thus perpetually renewed by the deposition of pure copper, and the counteraction of zinc or any other precipitated metal effectually prevented. The minor affinity of the copper for the acid, however, still remains, and such an opposition could only be effectually avoided by the employment of platinum plates, perpetually renewed by the decomposition in the circuit of chloride of platinum; such an arrangement would be perfect, but too costly for ordinary applications."

This battery, the prototype of all chemical depolarising batteries, is worthy of attentive study. In it the hydrogen, instead of being deposited upon the copper plate, is oxidised to water by the solution of copper sulphate, and metallic copper in place of hydrogen is thrown down upon the copper plate. Polarisation is thus entirely prevented.

If constancy of current were the sole requisite of a battery for electric lighting, the Daniell battery would be admirably suited to the purpose, but it will be remembered that a high electromotive force and a low internal resistance are also essential, and here the Daniell battery fails. The electromotive force of any copper zinc couple is low, and the internal resistance of the Daniell cell is high. The electromotive force might be raised by the device suggested by Daniell of employing platinum in place of copper, and solution of chloride of platinum in place of solution of sulphate of copper, but the expense would militate against the practical success of such an arrangement.

It was reserved for Grove—now the Hon. Sir W. R. Grove, one of her Majesty's judges, but then Professor of Chemistry at the London Institution—to overcome this difficulty, and to produce a chemical depolarising battery of high electromotive force, low internal resistance, and employing a comparatively cheap depolarising liquid. Daniell, as we have seen, had appreciated very clearly the advantage of a platinum plate, but his mind seemed so engrossed with his original idea of a metallic solution, as depolariser, which in decomposition deposits upon the plate dipping into it a layer of the same metal, that the possibility of finding a non-metallic depolariser does not appear to have suggested itself to him. Grove, however, saw this possibility, and by the substitution of strong nitric acid for the metallic solution achieved the success which Daniell had vainly sought for. For the first time the production of the electric light by the aid of a primary battery became possible on a practical scale; and the very year of Grove's invention the electric light was used for theatrical purposes at the Opera House in Paris.

Suggestions by Cooper, Walker, Bunsen, and Archereau quickly followed, and in the course of a few years the nitric acid battery had assumed its present convenient form.

It would be tedious to tell you of the many attempts to practically introduce the electric light which now rapidly succeeded one another. One of the most noteworthy instances of the employment of this battery is the electric lighting of the Cherbourg Docks, during their construction in 1858, whereby 1,800 men were enabled to work during the night, when work must otherwise have been suspended.

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In 1831 Faraday made the important discovery that when a closed circuit of conducting material—a ring of copper, for example—is moved in the neighbourhood of a magnet, so that the conductor passes from a position of one magnetic intensity to a position of a different magnetic intensity, a current of electricity is generated in the conductor, and that when the conductor is moved, so that a current is generated in it, more mechanical work is done in producing the motion than when no current is generated. In effect, this great discovery was that by the intervention of a magnet and a coil of wire, mechanical energy—the energy of the arm or of the steam engine—can be transformed into electric energy. Out of this discovery have grown the huge dynamo-electric machines of to-day, which, as generators of electricity for lighting purposes, have almost driven voltaic batteries from the field of competition.

Why is this? Why is it that a dynamo-electric machine should be almost universally preferred to a voltaic battery for the production of the electric light? It is a question of cost—of the relative cost of the two methods of producing an electric current.

(TO BE CONTINUED.)

TELEGRAPH TARIFFS.*

BY COLONEL WEBBER, C.B., R.E.

[In accordance with the promise contained in the leading article in our issue of May 31, wherein we criticised Colonel Webber's proposals as stated in the following paper, we reprint this paper, despite the fact that it was read more than a month ago.—Ed. *E.*]

The subject which your council has requested me to bring before you this evening is one that would require far longer than the limited time at our disposal to permit of its being exhaustively dealt with in all its branches.

As the introduction of the sixpenny rate in our own telegraph service has been so long under discussion, in and out of Parliament, and as a resolution "that the time had arrived for a reduction" was adopted by the House of Commons in March, 1883, and as the Chancellor of the Exchequer has, since that date, been carefully considering the conditions under which the reduction to a sixpenny uniform rate can be brought into force, it is hoped that the public ventilation of the subject within these walls may have the effect of establishing a cheaper rate, in one form or another, at an *earlier date* than is anticipated by the latest official announcements on the subject.

I am in great hopes that officers of the Post Office now present will find themselves in a position to discuss, criticise, or overthrow in fair argument, if they can do so, the propositions which I, as an old brother officer who hopes he has kept up his knowledge of telegraphy and its traffic, am able to lay before you.

In the public interest I shall urge on all who may wish to speak to endeavour to confine their remarks to the very narrow issue which you will find in the outcome of this paper.

To assist the audience in dwelling on the subject, tables are given with some foreign inland rates, and the corresponding value in English money for thirty-two words. Practically our rate of one shilling includes an average of twelve words in the addresses. By the following comparison, the figures of which are only approximate, it will be seen that, with the exception of Belgium, Holland, Switzerland, and Italy, we get most for our money, when it is considered that our free delivery is for one mile, and theirs for one kilometre.

Inland Tariffs.

Word rate with a minimum, addresses not free.

	At 32 words in message. s.	d.
France.—First 10 words, 50 centimes	1	3
Belgium.—First 15 words, 50 centimes	0	10¾
Each additional 5 words up to first 50, 10 centimes	0	8½
Each additional 10 words up to first 100, 10 centimes	0	4¾
Italy.—First 15 words, 50 centimes	0	10¾
Each additional word, 5 centimes	0	5¾
Spain.—First 15 words, 100 centimes	1	9½
Each additional word, 10 centimes	0	1
Local telegrams (half-rates)	0	10¾
Russia.—First 10 words, 11d.	3	1½
Each additional word, 1d.	0	1
Local telegrams, 8d.	2	3
Holland.—Surtax, 3d. Each word in the message, ¼d. Lowest charge ½ a franc	0	11½
Switzerland.—Nearly the same as Holland.		
Portugal.—Surtax, 25 centimes Each word in message, 5 centimes	1	6½
Germany.—Surtax, ·20 mark Each word, ·05 ,,	1	9
Towns, ·02 ,,	0	8½
Austria & Hungary.—Surtax, 24 kreutzers, 60 cent. Each word, 2 ,, 5 ,,	1	10
Towns, 1 ,, 2½ ,,	1	1½
New South Wales.—Between all stations, except surburban— First ten words, 1s. Each additional word, 1d.	3	0
Between suburban offices— First ten words, 6d. Each additional word, 1d.	2	6
Delayed messages— First ten words, 6d. Each additional word, ½d.	1	6

Some distances to which messages are transmitted at the above rates—

Sydney to Tenterfield, North	475 miles
,, Albury, South	386 ,,
Tenterfield to Albury	161 ,,
Sydney to Hay, S.W.	454 ,,
,, Wentworth, S.W.	731 ,,
,, Wilcaunia, N.W.	711 ,,
,, Menindie, West	830 ,,
,, Bourke, N.W.	574 ,,

Account of the Nature of the Service Rendered by the Post Office in the Transmission of a Telegram.—The machinery of transmission may be classed as follows:—The offices; the *personnel;* the mechanical means; the electrical means; the porterage. The public does not probably realise the extent or nature of these means, nor the organisation that is necessary to set them in motion, to keep them at work, to provide supervision, and to utilise these means profitably.

The Office.—Each telegram must pass through two, the forwarding office and the receiving office; often through more than two, having, more frequently, to be *transmitted* at one or more intermediate offices. The forwarding office requires a counter where the sender writes his message, another where the clerk receives, passes, and prepares it, and a third where the telegraph clerk signals it to the next station on its route. For this operation the white paper Form A is used, and this, the original message, remains the property of the Postmaster-General. The tariff of this message, as is well known, includes free addresses, one shilling being paid for 20 words; but as this rate increases for every additional five words, the principle is that of a word rate; in fact, it is altogether an empirical tariff. The *postal* feature of it is, that encouragement is given to full addresses. The counter clerk is not saved the labour of counting the words if the message is not written clearly in the spaces provided on the form, or if the four lines are nearly or quite filled. Passing 21 words by accident for 20, and charging 1s. instead of 1s. 3d., would be visited on a clerk by the punishment of fining. If the sender's message is for a place beyond the United Kingdom, the counter clerk must also understand how to charge and deal with it.

The Instrument and its Clerk.—The instrument clerk, or the operator. His knowledge must not only include what may be called the language of telegraphy—meaning the various classifying code signals, which must be sent as well as the message itself—but also the actual art of signalling with the Morse code. Omitting reference to the use of telephones or alphabetical instruments for signalling purposes, I will only draw your attention to this art, in which the young alone can become really efficient. Few realise its difficulty, and the fact that no one can become a thorough Morse clerk without years of practice. I do not refer to those who are just efficient enough to spell out the words slowly, either in sending

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or receiving, or who, even when quick at sending, must resort to the use of the printed Morse slip of paper to read, and whose ears have not acquired the wonderful power of reading groups of signals as words, but to those to whom the whole operation of sending and receiving has become a language of the hand and ear.

The Mechanism.—Part of the mechanical means by which the message reaches its destination sometimes consists of a pneumatic tube from the counter to the instrument room, occasionally worked by a bellows. The well-known mechanism of the Morse printing key, by which the long and short electrical impulses are communicated to the conductor, the source of energy in the battery, and the insulated conductor starting from the instrument, at first covered with gutta percha, then crossing house-tops, roads, fields, and rivers, insulated by the air throughout its length, except where carried on insulators at the points of support, and so away to the distant station containing the receiving instrument, are too well known to need description. It is sufficient to give an idea of the value of such a line of communication 100 miles long to say that if the poles conveying it carry several wires besides, the cost of such a plant is, roughly, not less than £1,300.

The Intermediate and Terminal Offices.—But if the message has not completed its journey on reaching the station at the first 100 miles, the receiving clerk, who has been warned by a special prefix, selects a yellow coloured form (B) in place of a red one, and the message, when taken down, is passed to the clerk working the instrument on the line reaching to the office of destination. Again, similar means, physical, mechanical, and electrical, are brought into use, very slightly varying in operation according to distance, and the message eventually reaches its terminus, to be taken down on a red coloured or C Form, and duplicated by means of a second sheet with carbon paper between. The original is kept, and the manifold copy sent to the counter clerk in the public office, who, having recorded it, places it in an envelope, addresses it, marks outside the time of despatch, the charge of porterage beyond one mile, and despatches it by a telegraph messenger boy in waiting. The Post Office, it will be seen, preserves at least two, most frequently three, copies of each message that is carried. These copies are eventually brought together and checked in a clearing-house.

Approximate Cost.—The annual cost of the route for the transmission of the message described above may be very roughly computed as follows, excluding the value of administration, which it would be difficult for any one outside the Post Office to assess. Let us adopt, as an example, the case of three offices, containing on an average (what would give) five instruments per office; and a route not passing through a first-class central station, the conditions of which are more complicated. Let us also use the simple example of a wire carried on a road line of telegraph, not on a railway line, where the Post Office pays exceptionally high rates for way leave and maintenance.

It works out as follows:—Share of three offices at £20, £60; share of two counter clerks at salaries of £70, £30; three instrument clerks at £50, £150; one boy (less receipts for delivery beyond one mile), £14; share of office superintendence, £30. Cost of plant: Three instruments and batteries, £60; 200 miles of line, £2,600—£2,660. Interest and depreciation at 7 per cent., £186; maintenance of road line at 12s. a mile, £120; supervision and sundries, £30—total, £680.

This total, after striking off a few for Sundays, represents an average of forty-three shilling messages a day. At a low rate of speed this work would occupy two hours a day. Probably in practice it would be spread over three or four hours. Thus, taking this example as a mere indication for the guidance of my audience, there remains twenty-one hours out of the twenty-four for this route to earn a profit. As the conditions of no two routes are precisely similar, and as some vary widely from that which has been given you, there is no desire to quote these figures as the basis of any but the most general conclusions. The object in laying this example before you is to give as simply as possible a general idea of the nature and value of the service rendered.

The Distance Rate.—At the earliest establishment of the electric telegraph, every one connected with it seems to have thought of no other classification of rates except that governed by distance. This was rational enough, as the administration of those early lines was largely in the hands of people who were connected with railway traffic, who at once turned their attention to making each communication pay for itself. While there were comparatively few messages, and any speed greater than that of a railway train was worth paying for, no better mode of charging could be suggested. All the means were expensive, the manipulation, the instruments, and the line, and no acceleration was attempted which increased their cost; hence distance rates commended themselves at once. With three great companies competing before 1870, the mode of charging by distance lent itself effectively to competition. The United Kingdom Company, which started with a uniform shilling rate, was nearly stifled, and had to adopt the distance rate.

Sir James Anderson on the Effect of Reduced Tariffs on Telegraphy.—In 1872, this well-known telegraph manager published a pamphlet on telegraph tariffs. At the time he wrote (1872) it was still under discussion if private undertakings could afford to reduce rates, although the results in Switzerland, Belgium, and the United Kingdom gave ample proof that judicious reduction gives splendid results. His conclusion was that the highest return upon the capital invested is obtained from a high tariff, and that competition would always check the extension of unproductive facilities to the public. Hence he believed that a monopoly was essential to the creation of a system which would be self-supporting, for the benefit of the public. We know that Mr. Scudamore never shared that belief with the Government of the day which obtained it from the House of Commons, and we know how that monopoly acted fatally in checking the reduction of tariff in this country (long since overdue) by inflating the capital account of the business. Sir James Anderson goes carefully into the reports from Belgium, and shows how the conditions of the *international* differ from those of the *internal* traffic. He eliminates from actual returns the abnormal stimulus of increased facilities, and discovers a normal rate of progression in the fourteen years with which he deals of 12½ per cent., which being independent of increased plant is a measure of the clear natural increment. He then obtains a comparison between the rate of progression of expenses and that of the abnormal augmentation of correspondence. With each of these figures he endeavours to show the large amount of profit sacrificed by lowering the tariff. His contention that the results of the working of *international* service in Belgium, on which reductions of tariff to the same extent did not take place, at first covered a deficit on the *internal* traffic, seems to be proved, and makes us cautious in accepting the Belgium figures of those days in their entirety. There is one point which I wish you to consider, which is that Sir James's personal experience was more built on the service of great arterial communications than on a network system. From this point of view, a word rate, subject to distance, would be most rational. Cables have a different capacity. If there is but one communication, nothing can prevent delay on messages. For example, if the offices at both ends are clear of message work at 9 a.m., and messages at the rate of twenty an hour be handed in by the public up to 12 o'clock, and the cable can only carry ten an hour, it is plain that the message handed in just before noon cannot be sent on till 3 o'clock, bearing with it three hours' delay in comparison with the message handed in at 9 a.m. Acceleration, therefore, in the first instance, would have little effect on the calculations of a tariff for such a line. Competition, as between the United Kingdom and America, immediately gives rise to the obligation to accelerate by duplication of the cable. The rate founded on distance, or in other words, on outlay, then becomes subordinate to time, and the application of that coefficient becomes a source of expense, showing that acceleration raises working cost. The converse of this receives illustration in the *Proceedings* of the Select Committee of the House of Commons in 1868 on the Electric Telegraphs Bill.

In the Appendix to the Report, No. I., page 8, there is a quotation of the view then held in Belgium by the Director of Telegraphs. He points out "that in fixing lower rates the Government by no means assured the same facilities to the public." They were told that—"They must not consider the half-franc telegrams would assure them either speed or accuracy. The message at the reduced rate should be considered as one that would be conveyed at about the speed of a railway train. If the public require acceleration they must rely on the half-franc message. For extra speed, or preference, or an 'express message,' two higher rates must be used." No really important sacrifice of speed was contemplated, for in the same report he claims for Belgium, then, a higher mean speed than in any other country; in fact, he made the ordinary message third class, and accelerated messages, for which more was paid, as second and first class messages.

The Telegraph Circuit, and its Working Conditions.—The term circuit, as many of those present know, is a telegraphic expression, intended to describe the popularly understood path between the terminal offices of the electric current in the one direction by the wire, in the other or return direction through the earth. A completely equipped circuit must include the operators. The conditions under which a telegraphic circuit is worked vary considerably in one country, and between countries. Some of those conditions may be described briefly, for instance, as regards the services of operators. They may be highly skilled male clerks, able to work at high speed for many hours at a stretch, possessing great readiness of resource; equally skilled female clerks, but with less physical capacity for endurance, and less resource in difficulties; clerks who in addition understand the simple maintenance of the instruments and batteries; others who require more or less the assistance of skilled maintenance men; clerks who are mere learners, or who have only experience acquired on needle instruments; others in country post offices, who are members of the postmaster's family, and occasionally his aged wife or youthful

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grandchild. In the United Kingdom there is a considerable variety of instruments in use, partly due to the original acquisition by the Post Office of the plant of various companies, and partly to the varying powers of the operators that have been mentioned. I am indebted to my friend Mr. Preece for an approximate list of the number of instruments of each kind in use in the postal telegraphs, exclusive of telephones :—Wheatstone A B C instruments, 4,183 ; needle instruments, 3,883 ; Morse recording instruments, 1,107 ; Morse sounder instruments, 1,712 ; Morse recording instrument, worked duplex, 283 ; Morse sounder instrument, worked duplex, 357 ; quadruplex, worked with sounders, 27 ; Wheatstone automatic, 173 ; Wheatstone automatic, worked duplex, 64.

Besides, there are conditions of speed of minor importance to the subject before us, and also conditions of maintenance of the lines due to weather, which are certainly different in a mild and moist, to those in a rigorous or dry climate. Lastly, there are conditions of supervision and superintendence, which are most evident to those who have been engaged in the operations of the service. It may be said that, in common with kindred operations, efficiency of service and remunerative results largely depend on these. A telegraph system such as ours is a huge machine, working day and night, stretching over a vast area, dependent on varying local circumstances, and yet subject to one general code of laws, rigid and yet elastic in their imposition. With nothing else that I know of can it be so well compared as the nervous system as described by Herbert Spencer. It is the most perfect example of centralisation, tempered by decentralisation, the balance between them being preserved exactly as the administrators are guided by the indications of demand and supply. And the more I have studied the subject the more it has struck me that only where the administrators have strained the application of natural laws there only has the service failed to extract the maximum of possible result. The superintendents of this beautiful machine must have an intimate acquaintance not only with the best possible work obtainable from the means used, both human and material, but also with the thousand militating occurrences to which every part of it is liable ; so that, while always striving for excellence, too much shall not be demanded, and waste arise in the opposite direction. That this supervision has been well guided experience proves. And I will endeavour to show you that the success of the ultimate objects for which it is contending, namely, producing efficiency of service for the public, must all turn on the proper understanding and use of one coefficient, namely, *time*; that the measure of cost and of accuracy must be subordinate to the expenditure of *time*. Those who have been engaged in this supervision, and who have had to investigate complaints about accuracy or delay, will be the first to acknowledge that the ultimate conclusion of their research had been chiefly governed by the condition of *time*; if any improvement in the future is to be reaped, it will be through tracing the fault, whether physical, mechanical, or electrical, home to its true cause.

The Capacity of a Circuit.—Like other machines, a telegraph circuit has a measurable capacity for work. As in the case of a line of railway, it can carry traffic continuously, subject to working conditions of speed and safety, service and maintenance. Railway managers could give you many examples of lines worked fully up to their maximum capacity, even verging on the insecure, and they would add that out of the needs of the public have arisen classifications of traffic, namely, into various speeds, that some lines have to be devoted entirely to high speed, other to slow speed traffic, and that from some lines the maximum result of capacity is obtained by working both, confining each to different periods of the 24 hours. We can all understand that in few cases will practice attain the theoretical capacity of a line worked with trains following one another, travelling at equal speeds, and with safe intervals, and equally we can understand that the best commercial result will be obtained by the manager who best adopts and dovetails all the means at his disposal to meet the demands of his customers. Again, we can all clearly appreciate that traffic itself is subject to classification in its varieties. Thus, with passenger traffic, it can be subdivided according as persons are ready, from various motives, to pay for various rates of speed. Similarly with the carriage of live animals and perishable and imperishable goods. But while the powers of the railway manager to meet these demands in equal variety are limited, it is undoubtedly the case that the first object is to do so, especially when under the pressure of competition.

Telegraph Traffic Commercially Worked.—Now, to a much smaller degree, telegraphic traffic is subject to the same influences, if its management is truly commercial in its instincts. In using the word "commercial," I ask my audience to admit that in whatever way we regard the service of the public by a department of the State, the word "commercial" equally applies whether the system is worked at a loss, or without loss, or at a profit. Whatever the result, "commercial" working will mean working on a basis ; first, of extending facilities to every point to which private undertakings would extend it under the influence of competition ; second, of working on sound economical principles. It is true that when the State first took over the telegraph companies' business, many of the early extensions were very uncommercial ; but this was a weakness from the effects of which fifteen years' working has long ago recovered, and which for many years has been counteracted by the exactions from localities of guarantees to cover at least working expenses before extensions are permitted. If true commercial instinct is to be exercised in the management of our telegraphy, it would appear that, somewhat in the way I am attempting to describe, every circuit should be used in such a way as to obtain from its use the maximum gross revenue. As for all other kinds of means of transport there is a market ; the commercial instinct seeks the market and develops it, which means organising a system which will extract from it all that can be gained. Thus Pickford, Chaplin and Horne, in England, and Bianconi in Ireland, created a business ; if the demand had not been latent, they could not have made it pay. A department of the State serving the public, if the object is not to pay, should obtain still better results. If it is seeking to bring revenue into the Exchequer, it ought to produce quite as good results, with several advantages which no private undertaking can have.

Development of the Postal Telegraphs.—Let us inquire for a moment how far the Post Office has developed the latent telegraph as business in the country. They carry, say, 26,000,000 of telegrams, as against 8,000,000 before 1870 carried by the companies. This marvellous result has been obtained working on almost precisely the same main lines as when the Government first took the telegraphs in hand. Those broad lines have been a maximum of speed at a nominally uniform charge ; and, without considering the lessening of speed due to the means which, for economy of working, have been adopted in circuits of least importance, doubtless the highest results possible under those conditions have been obtained. The question then remains—Has the rigid adherence of these main lines of procedure obscured their vision, and prevented their discovering outlying regions of profit waiting to be reaped, greatly to the advantage of the public, and to the increase of revenue on the lowering of rates ? Ought we, out of pure gratitude for what has been done, to shut our eyes to this inquiry, and decline to allow that the Post Office may err, or have its vision narrowed within the range of the great reservoir of custom, which it has not only tapped exhaustively, but also developed in size ? The Society of Arts, years ago in the van of the movement which led to the acquisition of the telegraphs by the State, and always ready to place its arena at the disposal of the public for discussion, ensures, by its countenance of such an investigation as this, that it will be treated in the fairest spirit, and that every question or objection shall have the most serious consideration.

Possible and Actual Capacity of Existing Circuits.—Let us look at the possible capacity of the instruments of which I have already given a list :—

	Messages per annum.
A Wheatstone A B C instrument has an hourly capacity for 34 word messages of 15, or in 12 hours of 180. This, for 2,092 instruments for 310 days, gives a total of	116,705,700
A needle instrument has an hourly capacity for 25 messages of 34 words each, or in 12 hours of 300 messages. This, for 1,942 instruments in use, gives for 310 days	180,559,500
	297,265,200

The figures are so enormous, and representative of nothing within the range of probability, that it is is only necessary to mention the gross receipts at a shilling a message would amount to £14,863,260. In actual practice these instruments, at a very low estimate, probably forward on an average—every 2 A B C instruments, 6 messages a day ; every 2 needle instruments, 10 messages a day.

	Per anum.
Representing—A B C....................	3,891,120
Needle	6,018,200
Total	9,909,320

Which, at one shilling, amounts to £495,466, or 1-29th of the possible capacity. The same calculation applied to the Morse recorders and sounders, allowing them a message of 34 words capacity of 30 and 35 respectively, gives a possible capacity representing £8,663,880 ; and this in actual practice, allowing 20 messages a day for recorders, and 25 for sounders, amounts to £513,440, or 1-17th of the possible capacity. These figures, however approximate in their accuracy, are sufficiently based on fact to convince you that there is a very large margin of time during each day when circuits are idle, and when the mechanical and electrical machinery is at a standstill.

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Utilisation of Spare Capacity.—The question immediately arises how to utilise a portion of it. I have only dealt with twelve out of the twenty-four hours. The Post Office already utilises a proportion of the remainder of the twenty-four hours on many circuits by working them for press messages, at rates so unremunerative that it is doubtful if they pay for the actual manipulation. I have only dealt with twelve hours of the twenty-four, because all offices are already open during that time, and in offices with one instrument only a manipulator is always present. This manipulator, I have assumed, now deals with 6, 10, 20, or 25 messages a day, according to the class of office and instrument. If he worked away steadily for eight of the twelve hours he would deal with 120, 200, 240 and 280 messages. It is not straining this demand on his or her powers to expect that half those numbers could be dealt with without increasing the labour staff. Again, in offices with two or more instruments, periods occur daily when neither instruments nor clerks are fully occupied. The larger the offices, the fewer or less frequent are these periods, for the following reason :—Although an office may open at 7 a.m. and not close till 9 p.m., the time during which all the instruments are at work is probably limited to between 11 a.m. and 3 p.m., then all the clerks are hard at work. For about two hours before and after those hours but half the clerks need be present; probably early and late only one or two are wanted. Thus, by judicious dovetailing of the hours of work of each operator, the full time of each is fairly occupied throughout most of his working hours. In the largest offices this can be carried out with great perfection, but in the vast majority of medium-size offices there exists a margin of available labour which can only be adjusted by having too small an establishment of clerks. Its effect is a certain delay in every message during the busiest hours, and the accomplishment of work during times of slight abnormal pressure of business, by allowing the operators to work *overtime.*

High Standard of Time Aimed at in Postal Telegraphs.—Fortunately for the public, and the well-earned and maintained credit for speed won by our postal telegraphs, the department has always aimed at accomplishing what is highly creditable, and unequalled in most other countries, namely, that a message is considered to be delayed when the time taken to deal with it in any one office exceeds ten minutes. Now, this is a very high standard to aim at, and it can only be maintained, in all but the largest offices, by a redundancy of the manipulating staff, so that the very effort to serve the public will, in the matter of time, necessarily result in a margin of unutilised labour, as well as of mechanical and electrical means. I know that postmasters exercise great judgment in applying spare telegraphic labour to postal work, and *vice versâ*, but there must still remain hours during which some labour is still available to work the machinery lying idle under its hand. But where are the messages which will require transmission? My answer is, they will be forthcoming by a lowering of rates, when accepted on the understanding that they are to be sent during those periods that the machinery is now idle. The history of all telegraphs places it beyond discussion that every lowering of rates of any kind produces increased traffic of one kind or another. If the increase proves to be greater than can be dealt with by the margin of labour I claim to exist, then additional labour and working expenses at cost price must be added. I believe that 1½d. per message in each office which deals with it will amply suffice. If the demand exists for cheap telegraphy under conditions of speed less than those now aimed at by the Post Office, why not supply it? Why give the public a uniform speed on all messages? Is it not rational to suppose that there are messages which will fulfil their purpose equally well in the mind of the sender if delivered in three or four hours after being handed in? Does it not at once appear evident that the elimination of every fresh message, now sent in its code turn with the most pressing messages, will add to the punctuality of the latter? Whether we call the first messages express, or the slow-speed messages deferred, does not matter. Does not a classification of this kind coincide with the fundamental law of the government by time of all the conditions of telegraphic supply and demand? If we analyse the means used in telegraphy for increasing speed, we find that it is entirely a question of cost.

Cause of Delay.—If a message is handed in at an office between 11 and 11:5 with six others, including counter work, the first of the seven is completed in, say, three minutes, the next in three minutes more, and so on, the seventh message will have accumulated over sixteen minutes delay on reaching the transmitting stations. Here other delays may occur, and while the first is got through within ten or twelve minutes, the fifth is not ready for delivery for more than half an hour after receipt. All delays of such a kind can be lessened by increasing means, duplexing wires, doubling the operators, and so on. The greatest speed of a Wheatstone automatic circuit is achieved by costly apparatus and unlimited labour at each end of the wire. Increasing the wire accommodation may have to be resorted to to keep down delay when all other means fail. Is it not a much simpler experiment, to save expenditure and maintain speed, to offer the public inducements, by cheaper rates for less speed, to select of its own accord the slower route, when first-class speed is not essential? If the only gain were to reduce the work during the busiest hours of the day, and confine it to the supply of the demand for higher speed, the result would justify the change. When it also means the occupation of circuits, where otherwise they would be comparatively idle, by work eminently not suffering from such delay, through the selection of the customers, there would appear to be a large balance of evidence in its favour. But if, also, the cheaper rate taps a reserve of message-sending not now sounded, and if the increase of traffic of this character largely exceeds the loss on the messages for which the cheaper means have been selected by customers in preference to the old rate, surely this increased efficiency of the fast service, and the added facility to the public of the slower service, would alone more than prove the soundness of such a measure.

Dr. Playfair's Committee.—I will now refer my hearers to a paper laid by me in evidence before Sir Lyon Playfair's Committee of the House of Commons, in 1876, suggestive of a scheme of "deferred" or "second-class" messages, and descriptive of the means by which I proposed to bring it into force. This had been the result of several years of constant observance of the daily working of the system in the district of which I was the divisional engineer, and of careful inquiry amongst all the persons in that district upon whom would fall the labour of bringing it into force. I was not met by one dissentient as to the practicability of the proposal. If I ever encountered objections, they were derived from the experience of the great central stations, where slackness of work is never apparent. I claimed, in 1876, no novelty for the proposal except that its essential feature was its perfect adaptability to the postal telegraph system. It claimed to tap a new source of revenue without materially diverting existing channels, and to utilise existing spare means with little change. It designs to leave the 1s. message alone with its existing conditions and facilities, and that the Post Office should accept a new kind of *petite vitesse* message, and forward it under certain conditions for 6d. This message, if thought well, might be called "second-class" or "deferred," the main condition of transmission of the messages to be, that no second-class is forwarded while a first-class message is on hand. The effect of this would be :—1. That the 1s. message would remain as it is (subject to alterations as to payment of sender's address). 2. In practice, the second-class messages would only experience serious delay in busy offices, on busy lines, during busy hours. 3. Local telegraphing in country districts and towns would be developed; and circuits now only occupied with a dozen messages a day at 1s. would probably lose half these, but carry 20 or 30 at 6d. when it was found that on local traffic no real delay occurred by using the lower class. 4. It was suggested that this class of message should include only ten words, and that free delivery should be only for half a mile, and the second half mile be charged 3d.; but there is no reason why the delivery should not remain as it is for 1s. messages. 5. It was foreseen that the public might at first adopt more largely the use of second-class messages than the revenue could bear, and it was pointed out that as soon as those who did so found their messages suffer in speed they would revert to the shilling rate, with the greater satisfaction of obtaining a somewhat accelerated service for their money. The working was provided for by distinguishing second-class messages by forms of a different tint, or by strongly marked bands, or by large figures.

TABLE A.

First Class.				Second Class.			
Estimated words in address.	Words in message.	Total.	Charge	Estimated words in address.	Words in message.	Total.	Charge
			s. d.				s. d.
12	20	32	1 0	12	10	22	0 6
12	25	37	1 3	12	20	32	0 9
12	30	42	1 6	12	30	42	1 0
12	35	47	1 9	12	40	52	1 3
12	40	52	2 0	12	50	62	1 6
12	45	57	2 3	—	—	—	—
12	50	62	2 6	—	—	—	—

At the instrument it was proposed that second-class messages should be placed at the bottom of those lying before the operator, below the first-class ones, and as long as any of the latter were waiting to be sent to allow the former to accumulate. But immediately a clerk had "got off" all his first-class he was to go on with the second-class till a fresh first-class reached him.

A table is exhibited (Table A) showing the number of words that would be transmitted under the two rates. It will be seen, assuming

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that a wire carries on an average 20 words a minute, it could earn 6d. a minute at the second rate.

The report of the House of Commons Committee referred to this in the following terms :—"The essence of this plan is that in small localities telegrams would be largely multiplied, and that wires which now remain comparatively idle for a considerable portion of the day would have fuller and more evenly distributed work. This proposal has the merit of not disturbing the ordinary 1s. messages, and offers cheaper rates for such as can be delayed with a minimum dislocation of the present system. There is no greater disturbance of uniformity in this plan than in the various changes of the postal system, in which higher rates are charged for greater facilities."

The Postmaster-General's Opinion on Deferred Messages.—On 23rd July, 1880, Mr. Fawcett expressed himself adverse to the proposal when replying to a deputation of this society in the following terms, thus :—"There has been another suggestion made which I think it well to refer to, as I believe it has been discussed in public, that you should have two rates of charge ; what are known as 'deferred' telegrams charged at cheaper rates. For instance, those persons who go to the City telegraph office and pay 1s. for a telegram should have it sent off at once ; those persons paying sixpence should have their telegrams sent off when all the shilling telegrams have been got rid of. So far as I am concerned, I never could sanction such a scheme as that. It seems to me to have this fatal blemish that it would always impress the public with a sense of unfairness, and every person who did not get his telegram sent off, or receive it so quickly as he expected, would think the delay was owing to a preference given to a more influential or wealthy sender. It seems to me a principle of cardinal importance to maintain that there should be no distinction of persons—no distinctions with regard to preference—but that, as regards the first person who goes into a telegraph office, that the office should send his message first. If any departure is made from this principle, I am afraid that all confidence in the fairness of the telegraph service would be removed."

It is with the greatest deference to his wisdom and position that I venture to ask the meeting to consider for one moment the Postmaster-General's objections to establishing two classes of speed, for two rates of payment, for the carriage of telegrams. How far his reply was satisfactory to the deputation from this society I cannot say, but you will not be surprised if I ask you all not to feel in any way satisfied with it. The Postmaster-General recognises none of the financial and commercial advantages of the plan ; he offers no objections to it on account of any difficulty in working ; he simply adopts what I may call an eminently postal view of it. When I call it by that name, I mean that it is one of the oldest forms of answer employed by the Post Office when pressed from the outside to make any changes not originating within its own walls, namely, to say that the public would not like any change. This well-known objection has been in its time used against the Post Office Savings Bank, Insurance, and Parcels Post, prior to the birth of each, and their greatest opponents dwelt within the walls of St. Martin's-le-Grand. However, like all sound schemes, after an interval in each case, the wisdom which predominates within that world-famed establishment weighed down the scale, and the boon was granted. I must say that I am too great a believer in the soundness of Mr. Fawcett's own teaching to believe that he really thinks the public will object to two kinds of telegrams, more than they object to two classes of railway carriages or trains. They do not object to the different speeds in book and parcel post. They are quite able to understand paying differently for different speeds, and when the payment and selection is in their own hands, where is the reasonable suspicion of preference or unfairness? Uniform rates possess a fascination for some people, but what has become of the uniform rates within the Post Office itself? Is not its uniformity subject to the coefficient of weight for letters, and number of words for telegrams? Why not try the time rate? It is true the British public has been educated by the postal telegraph system, on unsound principles, to know nothing about the costliness of speed in respect of telegrams, and they mostly believe that the value of the service rendered is measurable by the number of words. But is it ever too late to restore the British mind to a healthy state on any subject? In Belgium the value of acceleration in the transmission of letters is recognised as having a distinct value, and facilities are given by which letters can be sent from place to place in less time than is occupied by the ordinary post. By writing the word "express" conspicuously on the envelope, and attaching an additional stamp of the value of 25 centimes to a letter bearing a 10 centime stamp, the sender secures preference for his letter over others, and it is sent to its destination by the quickest means. For instance, an "express" letter is sent by the next train leaving the place of collection by the Post Office, and is delivered at the other end of its journey by a special messenger. We do not hear that the Belgians look upon this as conducive to unfairness, or as giving the rich a preference over the poor man. One word more about the uniformity of rate question. There is a good deal about it in the *Proceedings* of the House of Commons Committee, on the Electric Bill of 1868 ; and it is frequently alluded to in the examinations of the late Mr. Scudamore ; also of Messrs. Harrison and Patterson, and of Professor Jevons. I am led to think, by a careful perusal of their evidence, that the uniformity they were advocating was as against what they called the irregularity and even "injustice" of the old companies ; and that the uniformity to which there has since been a tendency to wed us is an exaggeration and distortion of their views. Mr. Scudamore speaks of the advantage of uniformity of rate as "permitting the use of stamps," and as "simplifying telegraphy." He evidently alludes to the complications of the existing distance tariff, for later on he approves of the twenty word message at 1s. and to the fifteen word message at 6d., with a 1d. added five words additional. Again, uniformity was advocated by several witnesses as a necessary consequence on obtaining from Parliament a monopoly for the Post Office ; but Professor W. S. Jevons considered that the "sounder" principle was to arrange rates so that each communication should more or less pay for itself, and he expressly stated that he did not advocate a monopoly, and would rather rearrange rates than protect the system in that way. All the witnesses referred to the success of the uniform rate for postage, and examples were given how, in some cases, the actual cost of the transport of letters to the Post Office was 2d. and 3d., in others only ½d., as a justification for doing away with the distance tariff, then in existence, of 1s. for 100 miles, 1s. 6d. 200 miles, and so on. Looking back on these records, it looks as if the dislike to the existing tariffs, more than a real similarity between telegraph and postal work, weighed most with the advocates of a uniform word-rate under all conditions (amongst whom Mr. Goschen was prominent). Lastly, all the witnesses who spoke on the subject had then had no practical experience of the working of telegraphs. The difficulties which influenced their minds have long since disappeared, and exceptional alterations in tariff have been introduced into the postal telegraph service without observation. The caution which is slow in adopting alterations as improvements cannot be too much admired ; but it is well-known that the backwardness of public departments in this respect is more due to the inertia which "rests and is thankful," to the instinct of heavily worked officials to retard the introduction of thankless reforms, and to the deadening effect of official routine, which nips in the bud the energy of most of the men who, in other walks, would be in the van of advancement.

The Indian Telegraph Department.—Although administered under several essentially different conditions, its working and procedure as regards tariffs will interest the audience. One or two great differences are worth bearing in mind. The telegraph in India is essentially a European service, and English is used ; it cannot yet be said to be in use by the millions of our fellow subjects in that country. It is much used by the State and by local governments, the numbers in 1882-3 of State messages to private having been as 247,000 to 1,103,688. The distances in India being very great, a telegram often takes the place of a letter. As regards a very large proportion of the traffic, time is of less importance than here, distance is a more influential condition. Founded on the experience of a far longer period of State control than this country has enjoyed, we find the Government of India expressing itself in November, 1881, as "willing and anxious to forward any scheme for developing and facilitating communication by telegraph, so far as this can be done without risk to the interest of the general tax-paying community ; but in the interest of that community it is essential that the telegraph service should be self-supporting." In pursuance of this object, we find that the Government approved on that date of a scheme for the "revision of the tariff, which, affording room for a very considerable future reduction in rates, will admit of a large expansion of the traffic without necessitating additional expenditure on increasing the number of the wires. The main feature of this scheme consists in the introduction of arrangements which will permit of the disposal of message traffic in order of urgency, instead of, as at present, in order of presentation of messages. The minute in Council recognises that in the case of commercial and State telegrams almost the whole are tendered for transmission during the business hours of the day, the result being a great pressure of work for a few hours, while for the rest of the day and night the wires are comparatively idle." As the "telegraph officials cannot be the judges of the comparative urgency of messages," it authorises the "Director-General to introduce, in addition to the 'ordinary' class of messages, two other classes, 'deferred' and 'urgent,'" the latter taking priority, and the former following the ordinary, when they have been worked out, the rates being :—Urgent, Rs. 2 ; ordinary, Rs. 1 ; deferred, Rs. ½, with free address. His Excellency the Governor-General in Council "believes that the introduction of the deferred message system . . . will prove a very great convenience to the public in improving the service for transmission of really urgent messages, and will enable a large reduction in

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average cost of telegraphing to be made, owing to the facilities it would give for utilising the wires for a greater proportion of the twenty-four hours than is possible under the present system." The special suitability of the deferred system to the long distances in India is exemplified by the condition that the Department does not bind itself to deliver these messages at their destination before early the following morning. Although the nature of traffic thus provided for in India would largely be carried by the post in this country, it is vital evidence to the existence of unearned revenue and undeveloped public facility that the system of "deferred" messages has been adopted in our great dependency. The Departmental Report for 1882-83 gives the total percentage of each class of inland messages dealt with in the last two years as follows :—

STATE MESSAGES.	1881-82.	1882-83.	PRIVATE MESSAGES.	1881-82.	1882-83.
Local	0·65	1·04	Local	0·43	0·64
Deferred	62·70	56·06	Deferred	22·03	32·06
Ordinary	7·12	11·10	Ordinary	72·64	60·90
Urgent	29·53	31·80	Urgent	4·90	6·40

The large increase in the last year of private deferred messages over ordinary shows the popularity of the former class. The value of the inland traffic in the above two years, and in the previous two, before the new system was introduced, shows great encouragement, viz., under private messages.

	Number.	Value Rs.
1879-80	1,037,330	15,32,153
1880-81	1,044,107	14,08,582
1881-82	1,035,137	13,16,851
1882-83	1,189,437	13,86,630

The increase in wire mileage between the last two years was as 58,219 to 61,184.

LEGAL.

Muirhead v. the Direct United States Cable Company.

This case came before Baron Huddleston in the High Court of Justice on the 24th inst. Mr. Webster, Q.C., Mr. R. S. Wright, and Mr. Moulton were counsel for the plaintiff; Mr. Finlay, Q.C., and Mr. Hunter appeared for the defendants.

This was an action for the breach of an agreement by which the defendants acquired the right to use upon their telegraph cable between Ireland and America an invention known as the duplex system, of which the plaintiff was the patentee. The agreement was entered into in August, 1877, and it was provided, among other things, that while the duplex system should "operate satisfactorily" the defendants should pay for its use £2,000 a year, to be paid quarterly; and it was further provided by another article in the agreement that if a total interruption of telegraphic communication took place payment of this sum should cease during such interruption. In conformity with this agreement, the duplex system was applied to the defendants' cable in 1877, and it was admitted operated satisfactorily until April, 1882, when a fault was discovered in the cable, which rendered the duplex system useless. Messages, however, continued to be sent backwards and forwards on the simplex system, and the royalties continued to be paid until the following year, when the defendants, relying upon their agreement, held they were not bound to pay the instalments, as the duplex system, through no fault of their own, had ceased to "operate satisfactorily." Since then two quarters' payments had become due, to recover which the present action was brought. The question between the parties turned upon the construction to be put upon the agreement, the plaintiff contending that the words "operate satisfactorily" meant while the system as a system should operate satisfactorily, independent of its applicability to the cable, and, further, that if, as a fact, the system had not worked satisfactorily, this was because the defendants had failed to carry out an implied obligation to maintain the line in reasonable and proper repair. The defendants, on the other hand, disputed that there was any such implied obligation, and contended that the contract was dependent upon the satisfactory operation of the system, unless the failure to operate satisfactorily was brought about by some fault or neglect of their own. With regard to the facts, it was proved that the system had suddenly ceased to work satisfactorily in April, 1882, and that the cause of its so doing could not be ascertained. The locality of the fault, however, was well known, but to remedy it, it was shown, would involve an outlay of between £30,000 and £80,000, and that the messages could still be sent on the simplex system without it. The defendants urged that to incur such an expense was unreasonable, and was not required by the contract.

Baron HUDDLESTON, at the conclusion of the evidence, gave judgment in favour of the plaintiff. The fair meaning of the section which contained the words "should operate satisfactorily" was that the royalties should be paid so long as the duplex system operated satisfactorily upon the state of things as it then was and on the line which the defendants had, and this implied that the defendants should keep their line in that condition, and do nothing to prevent the successful operation of the system. It was undisputed that the duplex system was applied and did operate satisfactorily for five years, and it was for the defendants to show why they should not pay the instalments which had subsequently become due. They had not shown that the fault was in any way due to the plaintiff; but he did not decide the case against them for failure of proof, but because it was clear there was a fault in 1882 which had not existed in 1877 when the duplex system was applied to the cable. Was this a fault which was contemplated by the agreement? There was a clause which provided what should be done in case of a total interruption, but the contract was silent as to what should be done if the defendants did not repair. It was clear that the repair was feasible, if costly, while it had also been shown that the company had a reserve fund of no less than £340,000. Ought they, then, to repair? He was of opinion that they ought, and that if they ceased to make their line available for the application of the plaintiff's system they were bound to pay under the agreement. He therefore gave judgment for the plaintiff for £1,000, with interest, but as the case was an important one execution would be stayed upon terms.

Central News v. Eastern Telegraph Company.

An application for a new trial of this case was made on Thursday, before Mr. Justice Field, Mr. Justice Manisty, and Mr. Justice Lopes, in the Queen's Bench Division. The Court was of opinion that it would be useless to proceed with the matter until the Lord Chief Justice gave his judgment on further consideration, and the arguments were therefore not proceeded with.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JUNE 25.		BUSINESS DONE WEEK ENDING JUNE 25. Highest.	Lowest.
Anglo-American	31,	32	31½	31
Do. Preferred	55,	56	56	55½
Do. Deferred	6½,	7	6 11-16	
Brazilian Submarine	9¾,	10	10 1-16	9⅞
Cuba	9¾,	10¼	10¼	10⅛
Do. Preference	16½,	17½	—	—
Direct Spanish	4½,	5	—	—
Do. Preference	14¼,	14¾	14⅝	—
Direct United States Cable	9¾,	10	9⅞	9⅝
Eastern Telegraph	10⅞,	11⅛	11⅛	10⅞
Do. 6 per Cent. Preference	13½,	14	13 11-16	13½
Do. 5 per Cent. Debentures, 1899	103,	107	—	—
Eastern Extension	11¼,	11½	11 9-16	11
German Union	9¼,	9¾	—	—
Globe Telegraph and Trust	6½,	6¾	6⅝	6½
Do. Preference	12¼,	12½	12 7-16	12 5-16
Great Northern	13⅞,	14⅛	14⅛	13⅞
Indo-European	30,	31	31¼	30⅝
Mediterranean Extension	1¼,	1¾	—	—
Do. Preference	2,	4	2½	—
Reuter's	8,	8½	—	—
Submarine	153,	158	156	155
West India and Panama	⅝,	⅞	⅞	⅝
Do. 1st Preference	6,	6½	6¼	—
Western Brazilian	5,	5½	5¼	—
Western Union 7 per Cent. 1st Mortgage	121,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	106	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	3-16,	5-16	¼	3-16
Oriental	⅛,	⅜	—	—
United Telephone	9¾,	10¼	10 9-16	9⅝

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1⅜,	1⅝	1⅝	—
Do. (fully paid)	3,	3½	3⅝	—
Hammond Light (£3 15s. paid)	⅜,	⅝	9-16	½
Eastern Electric (£4 paid)	—	—	—	—
Swan	⅛,	⅜	⅜	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	30½,	31½	32½	31
India Rubber, Gutta Percha, and Telegraph Works	20,	21	21¼	20¾

TRAFFIC RECEIPTS FOR MAY, 1884.

COMPANIES.	May, 1884.	May, 1883.	Increase.	Decrease.
Cuba Submarine	2,950	3,376	—	426
Direct Spanish Telegraph	1,562	1,641	—	79
Direct United States	—	—	—	—
Eastern Extension	35,910	32,156	3,754	—
Eastern Telegraph	51,537	42,960	8,577	—
Great Northern	24,920	—	—	—
Submarine	—	—	—	—
West Coast of America	4,240	—	—	—
Western and Brazilian	—	—	—	—

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NOTES.

NEW CABLE.—A telegram from Hong Kong, dated June 27, announces the opening of the Haiphong direct cable.

THE TELEPHONE IN GERMANY.—The town of Wilhelmshafen will shortly have a telephone exchange at work.

MAGNETIC OBSERVATORY AT ROME.—It is proposed by the Italian Government to establish a central magnetic observatory at Rome.

ANOTHER MEMORIAL.—A memorial to the Postmaster-General on the subject of telephony is being got up in Birkdale, near Liverpool.

INDIA RUBBER COMPANY.—The Bill of the India Rubber, Gutta Percha, and Telegraph Works Company was read a third time in the House of Commons on Monday.

METROPOLITAN BRUSH COMPANY.—A notice has appeared asking creditors of this company to send in their claims before 28th inst. to the liquidators at No. 2, Walbrook, E.C.

MEETING.—The twenty-fourth half-yearly ordinary general meeting of the Eastern Telegraph Company is to be held at 1 p.m. on Thursday next, at the Cannon-street Hotel.

CHINA.—The Great Northern Telegraph Company announce that a uniform rate of 10s. per word will now be charged for messages from the United Kingdom to all land line stations in China.

THE INSTITUTE OF CHEMISTRY.—A petition has been presented to Her Majesty by Mr. William Odling, M.A., F.R.S., and others, praying for the grant of a charter of incorporation to this Institute.

MANGANESE.—M. E. J. Maumené states that manganese exists in more or less quantities in vegetable matter. Fruits (he says) contain a notable proportion of manganese, as also do coffee and tea.

PROVISIONAL ORDER BILL.—Electric Lighting Provisional Order Bill No. 4 was passed through committee in the House of Lords on Monday last without amendment, and was reported to the House.

AMALGAMATION OF GAS COMPANIES.—The South Metropolitan Gas Company has absorbed the Woolwich, Plumstead, and Charlton Gas Consumers' Company and the Woolwich Equitable Gas Company.

HARROGATE ELECTRO-HYDROPATHIC COMPANY.—Mr. T. F. Smith, of 11, Queen Victoria-street, E.C., has been appointed official liquidator of this company, and all claims should be sent to him before the 14th inst.

CONVERSAZIONE AT KING'S COLLEGE.—A *conversazione* was given at King's College on Thursday evening by Professor Grylls Adams, President of the Society of Telegraph Engineers, about which we shall have more to say in our next issue.

OVERHEAD WIRES IN BRISTOL.—From our "Legal" column it will be seen that the Corporation of Bristol have claimed their right to the control of overhead wires in that city, and that this right has been legally recognised where wires pass over their freehold land.

THE LATE SIR WILLIAM SIEMENS.—A meeting was held on Thursday, the 26th ult., at the Institution of Civil Engineers, to consider what steps should be taken to raise an engineers' memorial to the late Sir William Siemens. A report will be found in another column.

PERSONAL.—We understand that Mr. J. S. Beeman, who has for two years past held the post of engineer and electrician to the South Eastern and Provincial Brush Electric Light Companies, is leaving their service at the end of the present month, in consequence of the change in the character of the company's business.

RESIGNATION.—We learn that Mr. C. H. Capito is leaving the Electrical Power Storage Company, in which he has held the position of chief electrical engineer for the last two years, and has now taken offices at 23, Queen Anne's-gate, S.W., in order to devote himself to the profession of a consulting engineer.

HEDGES' CUT-OUTS.—Mr. Killingworth Hedges has received the following certificate from the Technical Commission of the Vienna Exhibition:—"Hedges' patent cut-outs have been usefully employed in the work of the Technical Scientific Commission, and have proved themselves most admirably adapted to the ends in view."

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of June was 3,531, estimated to produce £3,150, against 3,120 messages, producing £2,688, in the corresponding month of last year. The traffic receipts for the month of March, estimated at £3,200, realised £3,296.

OVERHEAD WIRES.—The Wandsworth Board of Works has written to the local authorities of London pointing out that the Court of Appeal have reversed Mr. Justice Stephen's judgment restraining the erection of overhead wires in its district, and asking whether the local authorities will contribute to the cost of an appeal to the House of Lords.

THUNDERSTORM IN AUSTRIA.—*The Times* Vienna correspondent telegraphed under date June 29, as follows:—"A fearful thunderstorm broke suddenly yesterday over some workmen employed on the Lemberg-Czernowitz Railway. Three of them were killed, one was wounded, and five are missing. A train conveying surgeons and medicines has been sent to their assistance."

INTERNATIONAL PATENTS CONVENTION.—An Order in Council under the provisions of the Patents, Designs, and Trade Marks Acts, 1883, section 103, giving effect to the recent convention acceded to by Her Majesty's Government for the international protection of inventions, designs, and trade marks has just been issued, and will take effect from the 7th inst.

UNDERGROUND WIRES IN NEW YORK.—The Bill requiring all telegraph, telephone, and electric light wires in New York State to be put underground has been signed by Governor Cleveland. The Bill only applies to cities having 500,000 inhabitants or over. The wires are all to be buried by November 1st, 1885, or they will be removed by the local authorities.

ICHABOD.—A Paris paper says:—"The famous 'Métropolitain Electrique' of the Montmartre Boulevard, which used every evening to throw floods of light on obscure passers by, has ceased to exist. This company, whose lot was bound up with that of the Société Nouvelle, has suffered misfortune like the latter, and has consequently been obliged to abandon the spacious premises in which it had established itself."

POSTAL TELEGRAPHS.—The revenue derived from the Post Office telegraphs for the four quarters of the official year ending 30th June last was:—September quarter, £485,000; December, £435,000; March, £390,000; June, £440,000; or a total for the year of £1,750,000. For the year ending 30th

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June, 1883, the total revenue for the year was £1,735,000, so that the above figures show an increase of £15,000.

THUNDERSTORMS IN AMERICA.—According to a telegram from *The Times* correspondent at Philadelphia, the period of protracted heat and drought was broken on the 25th ult. in the Northern States by severe storms, much damage being caused by the lightning. Four persons were killed and ten injured by thunderbolts in Western Pennsylvania; two were killed in Wisconsin, and one was killed at Richfield Springs, New York.

NEW BOOK.—We have received from America a Government "Report on the Exhibits at the Crystal Palace Electrical Exhibition, 1882." It seems strange that we should have to depend upon a foreign country for a report on an exhibition of such importance as this one, for, so far as we know, no report of this kind has been issued in this country, unless Professor Adams's address to the Society of Telegraph Engineers be looked upon in this light.

DEATH OF MR. WATTS.—We regret to have to announce the death of Mr. Henry Watts, the well-known editor of Watts's "Dictionary of Chemistry," which took place at his residence, 51, King Henry's-road, South Hampstead, N.W., on the 30th ult. Mr. Watts's death will be widely felt not only amongst chemists but also among scientific men generally. He was a Fellow of the Royal Society, and a member of many others. He died at the age of sixty-nine.

ELECTRIC LIGHTING ON SHIPS.—The "Tasmania," which is the latest addition to the fleet of the Peninsular and Oriental Company, went for her trial trip a few days since, when an average speed of 15½ knots was obtained. She is 400ft. long, 45ft. beam, and 31½ft. deep, her tonnage being 4,500 gross, and h.-p. 4,000. She has been built by Messrs. Caird and Co., of Greenock, and has been fitted with incandescent lamps by Messrs. Siemens Bros. She sails from London on the 16th instant.

JOINT STOCK COMPANIES.—Notice is given in the *London Gazette* for the 27th June that the following companies will be struck off the register at the end of three months unless cause is shown to the contrary:—Anglo-Spanish Telegraph Company, Direct American Telegraph Company, Direct Atlantic Telegraph Company, Economic Telegram Company, Electric and General Engineering Company, Globe Telegraph Company, New Atlantic Telegraph Company, North Atlantic Cable Company.

COMMUNICATION ON TRAINS.—The *Ville de Paris* says:—"The Minister of Public Works has just invited the railway companies to adopt from now until the 1st July, 1885, apparatus to enable travellers who may be the victims of assaults to warn the officials of the train. These must be fitted in all express trains which travel 25 kilometres without a stop. No particular class of apparatus is insisted upon, and the companies are allowed to choose between mechanical, pneumatic, and electrical devices."

CARBON FOR BATTERIES.—M. Max Nische Niesky recommends the following process for making carbons for batteries: Take coke of good quality, crush it, and mix with coal tar. Compress the paste thus obtained in iron or bronze moulds and leave for several days. Then place in a furnace and gradually heat to a white heat without exposing the material directly to the flame; maintain this temperature for six to eight hours, then put out the fire and leave the moulds until cool, when the carbons can be withdrawn.

EASTERN TELEGRAPH COMPANY.—Subject to the final audit, the accounts of this company show, after placing £65,000 to the reserve fund, a balance available for dividend sufficient to pay the fixed dividend of 3s. per share, less income tax, being at the rate of 6 per cent. per annum on the preference shares, and a final dividend of 2s. 6d. per share with a bonus of 1s. per share, free of income-tax, on the ordinary shares, making with previous payments on account a total dividend of 6 per cent. for the year ending March 31, 1884, and carrying forward a balance of about £2,500.

TELEPHONE COMPANIES.—In the House of Commons, on Monday last, Mr. O'Shea asked the Postmaster-General whether in deciding on any suggestions which, in accordance with his invitation, might be laid before him by telephone companies, he would take care to exact such conditions as might protect the public against the evil effect of private monopolies which might be created by the amalgamation of, or by arrangements between, the companies.—Mr. Fawcett assured the hon. member that the considerations to which he referred would be carefully taken into account in dealing with the question of telephone communication.

THE NEW ORLEANS EXHIBITION.—The following details relating to this exhibition are of interest. The main building will contain 1,656,000 square feet, requiring 9,000,000ft. of lumber, 4,500 kegs of nails, and 5,000 boxes of glass, in its construction. It will be 60ft. high, with a tower 115ft., and it will have a music-hall in the centre with a seating capacity of 11,000. To light the building there will be 15,000 incandescent lamps, and the steam required for the whole structure will be upwards of 3,000 horse-power. About 1,000 men are engaged on the work of the main buildings, which will be ready for the reception of exhibits in August next.

THE NEW ATLANTIC CABLE.—The cable steamer "Faraday," which has been laying a portion of the Bennett-Mackay Atlantic cable, arrived at Queenstown on Thursday morning from Ballinskellig, on the west coast of Ireland. She commenced on June 28 to lay the shore end from the station at Waterville, and by July 1 had paid out 200 miles, which was successfully buoyed, and the "Faraday" returned to Queenstown to coal. She will not be long in receiving her supply, as three steam colliers are in Queenstown Harbour, sent direct from London for the purpose. On leaving she will proceed to pay out the 1,500 miles of cable she has on board, which will be spliced to the 850 already laid from the American shore, and it is hoped this will be accomplished in about a fortnight from her departure.

SUNDAY WORK IN POST OFFICES.—It appears from a statement of Mr. Fawcett's, in reply to recent questions in the House of Commons, that Sunday work in the Post Office in London has always been an exception, while in the provincial offices it has always existed. By the new classification, however, in 1881, the position of sorting clerks and telegraphists in the provincial offices with regard to Sunday work was considerably improved, as they are not ordinarily called upon to do more than eight hours' work in four Sundays, and if employed for a longer period than this are paid for overtime. When asked why such Sunday work was reckoned exceptional in London and not in the provinces, Mr. Fawcett said that there was less Sunday work in London, there being no delivery on that day.

BLESSING A LIGHTNING CONDUCTOR.—A remarkable service was conducted at Chichester on Saturday. In November last, during a heavy thunderstorm, the lightning conductor to

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the cathedral spire was shattered, the building escaping without injury, as was recorded in these columns at the time. The dangerous work of replacing the conductor has just been completed without accident, and at the close of the afternoon service on Saturday the Bishop of Chichester, Dean Burgon, Archdeacon Walker, and other clergy, followed by the choir, proceeded from the Cathedral to the spot at which the conductor enters a well. Here the choir chanted a psalm and sang a hymn, and the archdeacon, dean, and bishop offered prayer. An address, founded on the 37th chapter of Job, was delivered by the bishop, and at the close of the service a peal was rung on the Cathedral bells.

Arc Lamps on Incandescent Circuits.—A correspondent writes from Fall River, U.S.A., as follows:—"The Edison Electric Illuminating Company, of Brockton, Mass., are now using in connection with their incandescent system the 'Pilsen' arc lamp, with results which have exceeded their best expectations. They are placed on the same wires which supply current for the incandescent lamps, and are run two in service on each side of the system without the use of resistance coils, and give a very brilliant and steady light. The large porcelain globes not only give a better diffusion than the plain or frosted glass shades in common use with other arc lamps, but render almost imperceptible the occasional slight flickering which attends the burning of the best arc lamps in existence. In addition they are noiseless and economical, and compare favourably with any arc light in use in this country."

New Battery.—The *Bulletin* de la Compagnie Internationale des Téléphones describes a new battery that has been brought to its notice. The negative pole is of iron, and is separated from the other pole, which is of carbon, by a porous jar. The exciting liquid is a very dilute solution of commercial nitric acid. The negative electrode is made up of strips of iron closely bound together by two bands. The carbon composing the other electrode is in the shape of several hollow sticks perforated with holes. The whole is placed in a paraffined wooden box, and the tops of the electrodes are also paraffined. From experiments made with this battery it appears that neither current nor E.M.F. varied after 53 hours' working on a circuit formed of 36 volt Swan lamps requiring 8 amperes of current. It will work for 72 hours at the least without being looked to, and when exhausted only requires a little acid. It is somewhat cumbersome, however, as a battery of 2 cubic meters in size is required for lighting five lamps of a total candle-power of 40 candles.

The United Telephone Company.—In last week's Notes we stated that the United Telephone Company had bought up the London and Globe Company. The following paragraph in *The Standard* of Monday last throws a little additional light on this proceeding. It says:—"An agreement has just been concluded between the two Telephone Companies hitherto in existence in London, under which the United Telephone Company acquires the entire business, goodwill, and plant, together with the patents, of the London and Globe Company in the United Kingdom, for a sum of £25,000, to be paid in cash, and for a consideration of three-eighths interest in all profits, shares, or pecuniary advantage derived from the issue by the United Telephone Company of any subsidiary companies, the United Telephone Company thus reserving to itself five-eighths of such profits. It is also agreed that all litigation is to be stayed forthwith, and the appeal to the House of Lords with regard to the validity of the Edison patent is to be withdrawn, thus giving the United Telephone Company a complete monopoly of the telephone business of the United Kingdom, and rendering the Edison patent unassailable."

Telephonic Communication with Clubs.—In the House of Commons, on Thursday week, the 26th ult., Mr. Houldsworth asked the Postmaster-General whether he was aware that press news is supplied to the Ellesmere, Russell, Central, and 13 other clubs in Manchester; whether the department had power under the Act of Parliament to restrain the members of the said clubs from using telephonic communication for their own private business and affairs between these clubs; and whether he was prepared to withdraw the interdict issued by the department so far as applies to telephonic communication between clubs simultaneously supplied with the press news.—Mr. Fawcett said in reply that he was aware that press news was supplied to the clubs mentioned, as well as others in Manchester. The question of the legality of telephonic communication between separate clubs was quite distinct from that of the conditions regulating the supply of press news. He had already indicated what the latter conditions were in his reply to the hon. member's question of the 17th June (vide *The Electrician*, June 21st), and he felt that it would be inconvenient to enter upon a discussion of the legal position of the Post Office with regard to telephonic communication in reply to a question.

New Company.—A new company has been formed, under the title of the Electric Tricycle, Carriage, Boat, and Machinery Syndicate. The capital is to be subscribed by 100 subscriptions of £50 each, payable by instalments. Subscribers are to be entitled to be supplied with a tricycle or other apparatus in the syndicate's price list to the full value of his subscription, and are to be allowed to pay for the same by their subscription and dividend accounts being debited with the amount. The syndicate's electric tricycle is to be "capable of carrying two persons, and fitted with a battery and motor of sufficient power to propel the vehicle on level ground at the rate of six miles per hour, pedals being added for the sake of exercise and for obtaining a higher rate of speed when desired," and for all these benefits subscribers are to pay £50. If the battery is a primary battery the expense of maintenance will soon begin to tell on the subscriber's pocket; if a secondary battery, he must get it charged now and again, and he will not find people to do that for nothing. If he is anxious for an electric tricycle, let him have one built by a private firm and fitted by an electrician, and we do not think he will need to subscribe to the long-named syndicate, nor will his tricycle cost him £50.

The Faure-Sellon Volckmar Accumulator.—By invitation of Sir Daniel Cooper a considerable number of electricians and others interested in the progress of electric lighting assembled on the evening of the 29th ult., at 6, De Vere-gardens, Kensington Palace, at a *conversazione*, the main feature of interest being the illumination carried out by means of a large number of Swan incandescent lamps worked by the above-mentioned accumulator. This illustration of the capabilities of the apparatus was effected without a single hitch, the lamps in the various apartments being throughout the evening maintained at the same candle-power—one considerably above their nominal 20 candles. In the entrance-hall an illuminated fountain, worked by a small electric motor, in its turn worked by an accumulator, first attracted attention. A working model of Reckenzaun's electric railway, a number of "fairy lamps" worked by pocket accumulators, and other apparatus were also inspected with interest. A neatly and solidly-constructed 1 horse-power cell, weighing

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90lb., devised and exhibited by Mr. J. S. Sellon, was stated to embody some recent improvements. Great satisfaction was expressed by many of the visitors at the perfect success with which all the arrangements were carried out, and a splendid and tasteful illumination realised.

THE TELEPHONE IN FRANCE.—The following Projet de Loi has been laid before the Chamber of Deputies:—Article 1. The working of telephone lines conceded to private enterprise by the Minister of Posts and Telegraphs cannot be authorised for a longer period than five years, and under conditions fixed by a specification. This specification should stipulate, for the State's profit, for a tax of 10 per cent. at the least on the gross receipts. Article 2. These lines shall be worked either as permanent installations at the houses of individuals or as public exchanges. Article 3. The Minister of Posts and Telegraphs shall fix the tax to be paid for communications by means of public exchanges under the conditions of the law of April 5, 1878. He shall also fix, under the same conditions, the taxes for telephonic communications that the State might establish between towns. Dated Paris, 21st June, 1884. This law is merely an extension of that decreed on 26th June, 1879, which limited the concession of the right to erect and work telephone lines to five years, and reserved a tax of 10 per cent. on the gross receipts for the State. To show how profitable this tax has been we may mention that in 1879 it brought 2,424fr. into the treasury; in 1880, 15,616fr.; in 1881, 55,290fr.; in 1882, 142,637fr.; and in 1883, 217,145fr., whilst for the first quarter of 1884 it amounted to 63,353fr., and the second quarter is estimated to show a receipt of about 70,000fr. The concessions made in 1879 expire on the 8th September next.

FRICTIONAL MACHINES AND MOISTURE.—The results of R. Krüger's experiments in this direction may be summarised as follows:—1. The connection between the strength of the current of an induction machine and the moisture may be expressed by the formula $i = i_0 - a\rho^2 = i_0\left(1 - \frac{\rho^2}{\rho_0^2}\right)$; in which i is that strength of current which would be obtained if there were no moisture at all, and ρ_0 is that degree of moisture at which the machine would not work. 3. This formula holds for any degree of relative moisture with perfect accuracy. 2. The constant $\rho_0 = \sqrt{\frac{i_0}{a}}$ is greater as the velocity of rotation increases; that is, when the machine is rotated with greater velocity, its current first disappears at higher degrees of moisture than when the rotation is less rapid. 3. The quantity of electricity given by one turn of the plate when there is no moisture is essentially independent of the velocity of rotation; and the quantity of electricity which in this case passes through the section of the conducting wire amounts to $458{,}33\cdot80^5$ electrostatic units. Some observations intended to ascertain how far the current depends on the distance of the points from the movable plate, and, on the other hand, on the distance of the plates from each other, showed a decrease of strength with greater distance; but it was not possible to establish a definite law.—Translation of article in Wiedemann's *Annalen*, from the *Phil. Mag.* for July.

ATMOSPHERIC DUST AND AURORÆ.—Mr. Alexander McAdie, of Cambridge, Mass., writes to *Nature* as follows:—"I have had frequent occasion to note the intensity of the so-called 'rainband,' an absorption-band of terrestrial origin, due probably to the dust and water-vapour present in the atmosphere, and of just less refrangibility than the less refrangible of the D lines, and have at present two continuous records of observations, taken, in the main, five times a day, running back a year and a half or so. I have also a very thorough list of the auroral displays which have occurred for the same period in this vicinity. Granting that the aurora is an electric discharge in high regions of the atmosphere, or, more accurately, where its density is inappreciable compared with that at the earth's surface, and knowing that according to recent experiments (by Dr. Lodge and Mr. John Aitken) an electric discharge is capable of precipitating the dust particles in the atmosphere, it should follow that at times of auroral display, or immediately following, the intensity of this rain band should be at a minimum. Searching the records to ascertain if any such correspondence could be noticed, it is quite astonishing to find how distinct and well marked this variation in the intensity of the rain band at times of auroral occurrence is. The atmosphere is full of fine dust particles, and our very general though not yet decisively proven belief is that the aurora is somewhat of a glowlike discharge from electrified air strata, in whose vicinity the density of the dielectric is inconsiderable. The direct inference is that at such times the fine dust and vapour particles are deposited, made to settle, or uniting together, form an agglomeration, and become perhaps cloud neuclei. Perhaps other evidence on this matter can be elicited."

POSTAL TELEGRAPH CLERKS.—The following report appears in a recent issue of the *Birmingham Daily Post*:—"An enthusiastic meeting of the telegraph clerks was held at the Coffeehouse, Bull-street, on Saturday evening, for the purpose of receiving the report of the two delegates who attended the annual conference which was held at the Grand Hotel, Birmingham, on Whit Sunday. A committee was appointed for the ensuing year. The statement made by the two delegates gave great satisfaction to all members present. A hearty and unanimous vote of thanks was accorded them. A resolution was passed empowering the committee to draw up a petition asking the Postmaster-General to give payment for Sunday work. It was stated that while all other branches of the Civil Service worked eight hours per day, six days to the week, the postal telegraph clerks have to work at the rate of fifty hours per week, through having to perform Sunday labour about every four or six weeks. In London the male staff perform the night duty, while the Sunday work is paid for. Their provincial brethren cannot see the justice of this distinction, more especially as the telegraph companies used to pay for Sunday labour both in London and the provinces. In the Bristol offices soldiers are employed belonging to the Royal Engineers, who receive extra remuneration for Sunday work, while the ordinary clerks, who work side by side with the Engineers, receive no Sunday pay. This is looked upon as an injustice. Extracts were read from letters received by the Scotch clerks from several M.P.'s, showing their sympathy with the telegraph clerks, and promising assistance to remove the anomalies. The question of overtime and the practice in vogue at the Birmingham office was spoken of as one calculated to cause dissatisfaction, and thereby prejudicial to the interests of the public service.

ELECTRIC PROPERTIES OF FLAMES. — In Wiedemann's *Annalen*, Herr J. Collert describes the results of investigations on this subject, of which the following abstract appears in the Chemical Society's *Journal* for June:—"This investigation is a continuation of Hankel's researches on the electrical properties of the Bunsen and alcohol flames. The method of experiment was as follows:—A spiral of platinum was placed in the flame symmetrically with its axis, and connected with one pole of a Hankel electrometer, the other pole being in

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connection with the burner; the electrometer was also connected by a commutator with the poles of a zinc-copper pile conducting to earth. The principal results of the investigation are as follow:—I. The difference of potential is dependent on the material and the temperature of the mouth of the burner; an electro-potential series of the materials of which the burners are constructed can be arranged, of which iron is the most negative. II. The difference of potential is also conditioned by the position of the spiral; the point at which the greatest electromotive force is produced coincides probably with that of maximum temperature. This latter result probably represents the sum of several conflicting causes—firstly, by the rise of temperature the platinum is positively electrified; secondly, by contact with the hydrogen and carbonic oxide gas it is negatively electrified; and thirdly, in the cooler parts of the flame it is positively electrified by contact with steam and carbonic anhydride. As regards the second of these points, the experiments of Deville tend to show that the higher the temperature, the greater proportion of free hydrogen and carbonic oxide present; whilst Grove has shown that platinum is negatively electrified when in contact with these gases. III. The results obtained by the author agree with those of Elster and Geitl; the former finds for the E.M.F. of a platinum spiral in a Bunsen flame = 1·95 Daniell, in an alcohol flame = 1·43 Daniell; while the latter obtained the values 1·92 and 1·44 Daniell respectively.

Society of Telegraph Engineers.—On Friday a conference of the members of this society was held at the International Health Exhibition, when papers by Mr. Crompton and Dr. Stone were read. The former dealt with "Electric Lighting in Relation to Health," and the following is a syllabus of his paper:—Conditions of life under artificial light not so favourable to health as those under sunlight; causes of this (*a*) Those affecting the general health—(*b*) Those affecting the eyesight more particularly. Electric light nearest approaches sunlight, is therefore most favourable to health of all artificial illuminants. Comparison of the heating and air-vitiating effects of eleven different illuminants. Effects on the general health of insufficient light. Why artificial light, previous to electric light, invariably insufficient. Lighting by the arc and by incandescence; proper uses of both kinds. Effects of electric light on the eyesight. Fatigue to the eyesight from insufficient light, from unsteadiness, from bad colour. Comparative steadiness of arc and incandescent light; colour of both classes. Effects on eyesight of workpeople using both classes. Results of various well-known installations, House of Commons, Law Courts, Savoy Theatre, &c. Effects on children. Advantages of electric light indirectly affecting health. Safety. Additional pleasure from flowers, pictures, and all coloured decorative objects. General exhilaration caused by a plentiful supply of pure white well-diffused light. Absurdity of current ideas as to danger to person from use of electricity. Dr. Stone's paper was entitled, "The Physiological Bearing of Electricity on Health." In his opinion electricity as at present used is at once a source of danger, a possible cause of sickness, and a remedy. In all these cases it has been insufficiently studied, and continues to be ill understood. This condition of affairs is probably due to the fact that from the great subdivision of modern science, a competent knowledge of physics as well as of physiology is rarely acquired by the same person, whereas for accurate work it is essential that so powerful an agent should be measured by accepted units. What little has been done by the physiologists is marred by considerable errors as to the force actually in use. Dr. Stone alluded briefly to the dangers to sight, and more minutely to those affecting life and health. He thought the causes of death might be:—1. By catalytic action. 2. By thrombosis of the larger vessels. 3. By shock and syncope, due to action on the cardiac nervous system. Finally, he considered the remedies that might be applied, and the question generally from a physiological point of view. We shall have more to say about these papers and the conference in another issue.

The Electric Light in Mills.—Mr. Oliver Loring, of 19, Airlie-place, Dundee, writes to the *Dundee Advertiser* on this subject as follows:—"I have the pleasure to send you the actual upkeep of 120 incandescent lamps of 100 volts, running for 100 hours, which were fitted up under my superintendence a few months ago in a mill not many miles from Dundee, and which are still in use. The daily register of broken carbons, &c., was kept, and the estimate made at the end of the 100 hours by the manager of the works, who kindly gave me the details, so the source is utterly unbiassed. Besides, there was no skilled electrician in charge of the dynamo and lamps—only their own *employés*. The cost was as follows:—

Broken filaments, 9 at 5s.	£2	5	0
Broken lamps, 5 at 5s.	1	5	0
Broken by accident, 3 at 5s.	0	15	0
Coals, 1 ton	0	8	6
Sperm oil, 1 gallon	0	5	3
Total	£4	18	9

Now, these 120 Swan lamps replaced 169 gas burners, giving an infinitely better and decidedly a purer light than the latter. The cost of gas for 169 jets, consuming 4 cubic feet per hour for the 100 hours, at the rate of Dundee gas per 1,000 cubic feet, would have been—

$4 \times 169 \times 100 \times 3\frac{1}{2}$ shillings	£11	16	7
Less the 5 per cent. discount	0	11	10
Net cost	£11	4	9

This shows a balance of £6 6s. in favour of the electric light. In the above no account was taken for labour, as the attention required for the dynamo was about the same time as that required by a man fetching his safety lamp and lighting the 169 gas burners, since the lights were in various parts of the works. Nothing in either case being allowed for interest and depreciation, supposing we take £20 as such for the electric light for 500 hours, which is about the amount on the prime cost, reckoning it with Mr. Ewing at 8 per cent, this would be £4 additional to be added on. Still we have a balance of £2 6s. in favour of the incandescents. I need scarcely say that £4 for interest and depreciation is, in my opinion, about four times too much. I may also mention that the price of gas, where these are fitted up, is not 3s. 6d., but 4s. 7d. per 1,000 cubic feet, which makes the balance still greater. Without doubt the first outlay seems to be one of the chief causes why the electric light has not been adopted to any great extent in Dundee; but it is not the only one, as Mr. Martin must know by experience. I have found several others during my visits to the mill-owners. Allow me, in conclusion, to state that I trust shortly to produce a lamp costing about 3s. 6d., with an efficiency of three watts per candle-power, and having a life of 1,500 hours. This will reduce the prime cost considerably, and there is no doubt that with increased competition the manufacturers of electrical apparatus will reduce their prices before long. Then the gas companies whose charges are above 3s. per 1,000 cubic feet will find in the new light an antagonist greatly to be feared, and that time is not far distant."

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ELECTRO-CHEMISTRY.—Inorganic.

BY DR. G. GORE, F.R.S.

(CONTINUED FROM PAGE 151.)

Separation of Strontium.—Sr. Atomic weight = 87·5. A cation. Solutions of salts of strontium are slowly decomposed by simple immersion of metallic magnesium; after two days they yield a white deposit of strontium hydrate (S. Kern, *Chem. News*, Vol. XXXIII., p. 112; *Jour. Chem. Soc.*, 1876, Part 1, p. 684). Sodium amalgam decomposed a saturated solution of chloride of strontium with formation of strontium amalgam (Watts's "Dictionary of Chemistry," Vol. III., p. 886; *see* also Vol. VIII., Part 2, p. 1,829). Silicon does not separate strontium from heated fluoride of strontium. I heated to redness a mixture of the two substances, but no chemical change occurred. Caron deposited the metal by fusing its chloride with an alloy of sodium with tin or lead; the reduction was not effected by sodium alone (Watts's "Dictionary of Chemistry, Vol. V., p. 436). Strontium is electro-positive to magnesium, but not to potassium or sodium, in water.

Sir H. Davy was the first to deposit this metal by means of a separate current. He formed into a cup a pasty mass of strontium carbonate with water, placed the cup upon a platinum dish, and filled the cup with mercury as the cathode. By passing a current from 300 voltaic cells from the platinum to the mercury the strontium was deposited upon and absorbed by the mercury. Hare obtained the metal in a similar manner (Watts's "Dictionary of Chemistry," Vol. V., p. 436).

Bunsen obtained strontium in a precisely similar way to that of obtaining manganese (see *ante*), using a salt of strontium instead of one of that metal (Watts's "Dictionary of Chemistry," Vol. II., p. 437). Matthiessen obtained it from the fused chloride in the following manner:—A small porous cell was placed in a porcelain crucible, and both vessels nearly filled with anhydrous chloride of strontium, the level of that in the porous cell being the highest. The salt was melted so that a crust appeared on its surface. The cathode consisted of a thick iron wire, enclosed in the stem of a tobacco pipe, so that only 1-20th of an inch of it projected at the lower end, round which a very thin iron wire was coiled. The anode was a cylinder of sheet iron placed in the outer space. The cathode was immersed in the inner vessel, and the current passed; the metal collected upon it beneath the crust (Watts's "Dictionary of Chemistry," Vol. II., p. 438).

Separation of Barium.—Ba. Atomic weight = 137. A cation. Sodium amalgam separates this metal from a saturated solution of barium chloride at 93° C., and forms an amalgam. (Crookes, *Chem. News*, Vol. VI., p. 194; Watts's "Dictionary of Chemistry," Vol. VI., pp. 252, 253).

Barium amalgam may be prepared electrolytically either by depositing barium into mercury, or by contact of sodium amalgam with solutions of chloride of barium. It is a soft, pasty substance, somewhat gritty (Cailletet, Watts's "Dictionary of Chemistry," Vol. III., p. 886).

Sir H. Davy was the first to deposit barium by means of a separate current. He employed a wet mass of barium hydrate, carbonate, chloride, or nitrate, a cathode of mercury, and a powerful current from 500 voltaic cells, and obtained the metal as an amalgam with the mercury. Hare prepared it in a similar manner from the chilled and moistened chloride by means of a current from 100 cells (Watts's "Dictionary of Chemistry," Vol. I., p. 500). Bunsen electrolysed a boiling hot concentrated and acidulated solution of chloride of barium in a similar way to the one he employed in obtaining manganese, chromium, and calcium. It was more easily obtained than calcium (*see ante*; also *The Chemist*, New Series, Vol. I., p. 686; Watts's "Dictionary of Chemistry," Vol. I., p. 500). Matthiessen obtained banium from its fused chloride in a similar manner to that in which he obtained strontium (*see ante*; also Watts's "Dictionary of Chemistry," Vol. II., p. 438).

A solution of barium nitrate, electrolysed with platinum electrodes, yielded nitric acid at the anode and caustic baryta at the cathode (Sir H. Davy).

Separation of Lithium.—Li. Electro-chemical equivalent = 7. A monad cation. I observed that lithium was not separated by adding crystals of silicon to a fused mixture of the fluorides of lithium and sodium, nor were the crystals corroded or altered in weight. I also fused some fluoride of lithium in an open platinum crucible within a partially covered clay muffle, and electrolysed it by means of a current from six Smee's elements, and two flat platinum wire helices as electrodes, during thirty minutes. The conduction was free, and much gas was evolved from the anode only all the time. The anode was not corroded. A small amount of lithium was deposited upon the platinum cathode, and alloyed with it. By electrolysing a larger mass of the salt, with a current from six Grove's cells and a thick platinum wire cathode enclosed within, but insulated from, a platinum tube, to exclude the air from contact with the deposited lithium, the action was copious; with a gold anode the gold was corroded freely, and particles of it in large quantity floated in the liquid and united the electrodes. The cathode swelled greatly, and its lower end bent itself towards the anode, became quite grey in colour, and split in the direction of its length.

Bunsen was the first person who electro-deposited this metal (Watts's "Dictionary of Chemistry," Vol. III., p. 727). By electrolysing fused chloride of lithium with a current from four or six Bunsen's cells, an anode of gas coke, and a cathode of iron wire, he deposited silver white metal upon the wire (Watts's "Dictionary of Chemistry," Vol. II., p. 437). Schnitzler also electrolysed a mixture of the fused chlorides of lithium and ammonium by a current from 12 Bunsen's cells, and a cathode of iron wire, and obtained metallic lithium (*Jour. Chem. Soc.*, Vol. XXII., p. 961).

Separation of Sodium.—Na. Electro-chemical equivalent = 23. A monad cation. In a solution of sodic chloride, magnesium evolves hydrogen slowly, sodium hydroxide being formed, rendering the solution alkaline (S. Kern, *Jour. Chem. Soc.*, 1876, Part I., p. 684). Beetz observed that under these conditions a black suboxide of magnesium is formed. Carbon, also iron, reduces the melted hydrate or carbonate of sodium at a high temperature, and sets free the metal.

Sir H. Davy first electro-deposited sodium in the year 1807 by moistening its hydrate with water in a platinum capsule, which acted as the anode, dipping a platinum wire cathode in the salt, and using a current from a battery composed of 100 to 200 cells. He also deposited it more easily into mercury in a similar way to that already described under magnesium, and thus obtained an amalgam of the two metals.

In the electrolysis of melted sodic hydrate an anode of either platinum, silver, or copper dissolves in the liquid, and the respective metals are deposited upon the cathode (A. Brester, *Chem. News*, Vol. XVIII., p. 145).

Electrolysis of Sodic Fluoride.—NaF. Molecular weight = 42. I have noticed that crystals of silicon thrown into melted fluoride of sodium evolved bubbles of vapour, which exploded and burned with a yellow flame on arriving at the surface of the liquid. In a second trial, 7 grains of the dry fluoride in powder mixed with one grain of the crystals were heated to redness; the crystals lost ·15 grain in weight. I electrolysed a saturated aqueous solution of sodic fluoride by a current from six Grove's cells with platinum electrodes; gas was evolved from the anode, and emitted a powerful odour of ozone.

Electrolysis of Sodic Chloride. — NaCl. Molecular weight = 58·5. Hisinger and Berzelius electrolysed a solution of common salt with silver electrodes. Gas was evolved at the cathode, and after a time at the anode also. The anode became covered with argentic chloride, the liquid near it contained dissolved chlorine, and the solution near the cathode contained free soda. With lead electrodes the negative wire evolved gas, and received a deposit of crystals of lead, and the anode became coated with plumbic chloride. By electrolysing a solution of common salt, Higgins and Draper observed that chlorine was set free at the anode, and hydrogen gas and soda at the cathode. But if the cathode consisted of mercury sodium amalgam was produced. According to Matthiesen, a fused mixture of the chlorides of calcium and of sodium yields a deposit of the latter metal, when electrolysed in a certain manner (Watts's "Dictionary of Chemistry," Vol. I., p. 715).

(TO BE CONTINUED.)

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CORRESPONDENCE.

THE COST OF ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Permit me again, as shortly as possible, to encroach upon your space, and, in the first place, to express my gratification that Professor Ewing has so frankly met me and given the details on which his estimate was based.

For all practical purposes, I think it may be held that with the exception of the dynamos and their cost, the figures of the professor and those given by me agreed. But with regard to the dynamos (apart from cost), allow me to observe that I think my reason for preferring three machines instead of one will be perfectly obvious if you take into consideration the increased efficiency and diminished risk of accident. With only one machine, what would be the result if the belt slipped, or any other interruption were to occur? The whole place would be thrown into darkness in a moment, and endless confusion and annoyance arise; and not only confusion and annoyance, but the risk (indeed, almost certainty), of serious damage both to life, machinery, and goods. But with three machines this could not possibly happen unless through a thorough breakdown in the engine, for it is scarcely possible to conceive that all the three machines would break down and become useless at one and the same time. I venture to say, therefore, that it would be wiser to adopt my plan, as its advantages I am sure would be found to much more than outweigh the minor considerations of economy and efficiency suggested by the professor.

I presume Professor Ewing knows that the illuminating power of Dundee gas is very high, being 27 candles for a 5 feet burner, and for a 4 feet burner 22½ candles. I cannot, therefore, see how he makes out that my 400 lamps of 20 candles and 120 of 10 candles would give a total illumination considerably greater than that given by the 500 4ft. burners. I doubt he will find that it is impossible to use less than one 20 candle lamp for every gas jet. At least that has been my experience in Dundee. I do not know that the mill I referred to differs very much from the majority of other mills in Dundee, or has anything very exceptional in its construction, but, as you say in your article, "figures will prove anything—except facts." It is all very well to say that 500 4ft. burners will burn 1,000,000 cubic feet of gas in 500 hours. I formerly adopted much the same formula in estimates, but when I went to the millowners I was told my figures were much over the sum paid for gas, and I believe it will be found that all the mills in Dundee, almost without exception, use burners to burn not more than 3½ft. per hour, which gives a light equal to about 19 candles. This I believe to be a fact. If, therefore, you adopt 3½ feet per hour, then $3\frac{1}{2} \times 500 \times 500 = 875{,}000$ cubic feet, and at 3s. 6d. per 1,000 feet costs £153 2s. 6d., and with 5 per cent. off for prompt payment £145 9s. 5d. But 500 hours is too much to take, and if 400 hours is taken the cost will then be £116 7s. 6d. against the professor's £166 10s. as the cost of electric light. Do not the above figures, so far as the work in question is concerned, substantially support all that I have said, and may not the difference between the £100 of gas bill actually paid, and the £116 7s. 6d. which we might say they ought to have consumed, be put against the saving through careful manipulation of the gas in combination with the exceptional position and construction of the works?

It is needless for me to occupy your space by noticing the other details the professor gives, as although I might take exception to some of them the difference would not amount to much. I would merely remark that he does not err on the extravagant side.

But the whole thing resolves itself into this. It is quite evident that dynamo machines and incandescent lamps should be made and sold for a mere tithe of what is charged at present, and, until the companies reduce their prices electric lighting can never expect to enter into competition with gas in these mills. I shall be glad if the result of my communication is a substantial reduction in prices, and it was this I had in view in touching upon the matter. In fact it has borne good fruit already, as I have received letters from some of the companies offering to supply me with apparatus at a reduced figure—in one case at about 200 per cent. less than the figures quoted by me for dynamos. The prohibitive prices hitherto charged cannot for a moment be justified, and have been the means of retarding the progress of electric lighting. This is a matter which the shareholders of the various companies should have before them, and I venture to predict that a reduction of prices would be followed by a greatly increased demand, resulting in substantial dividends to the shareholders, fairly and honestly earned. Is not this the secret of the want of success of the various electric light companies? Without exception they have been ruinous to shareholders, who embarked in them as a sound investment. Have any of the companies ever fulfilled the high expectations their prospectuses suggested?

This letter has already reached to a greater length than I anticipated, but I believe it meets all the other minor points started in the letters of your correspondents.—Yours, &c.,

W. C. MARTIN.

Commercial-street, Dundee, 1st July, 1884.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the correspondence going on in your journal under the above heading, I agree with Professor Ewing's estimate of the prime cost of an electric light installation for 500 lamps.

In his estimate for maintenance, however, I would take exception to one or two items. Firstly, I think the cost of coals (8s. per ton) is rather too moderate. Secondly, the item £6, to cover "oil and attendance" is ridiculously small. Most people who have had any practical experience of the working of an installation of 500 lamps will agree with me in saying that it takes all a man's time to attend to the dynamos, belts, lamps, connections, switches, and the numerous other details connected with such an installation. And, furthermore, for proper attention it is necessary that the man in charge should possess more than average intelligence, and be capable of making connections, repairing fuses, detecting faults, &c. Therefore it is only reasonable to allow at least 25s. a week for attendance. Moreover, I believe that where there is a large dynamo working for a number of hours continuously every night, there must be some superior supervision to that of an ordinary workman, otherwise there will be occasional breakdowns, attendant, perhaps, with some injury to the machinery. And repairing of dynamos, we all know, is a costly matter, so that if the expense of an occasional visit of an electrician be added to the expense of a regular attendant, the item for attendance should be set down at something like £80. Then for oil and waste, I do not think 6d. per night too much for these, which alone would make, say, £7 10s. per year. Nothing is set down for renewal of brushes, which in a large machine might cost £2 or £3 per annum.

As to the item "renewal of lamps," Professor Ewing has overshot the mark completely. In an installation under my charge, the breakages, after working 1,000 hours, have been only 15 per cent. Therefore, I should rather allow 50 renewals in a case of 500 lamps for 500 hours, which I think would be ample, and would be £20 instead of £50.

My estimate, therefore, for current cost in the case in question would amount to (assuming the price of coals to be correctly stated) £220 instead of £166, as made out by your correspondent.

In conclusion, I think it only right that people should at length admit the fact that isolated electric lighting is more expensive than gas, and endeavour to reduce the expense both on prime and current cost, rather than continue to persuade themselves that an impossibility can be achieved.—Yours, &c.,

J. ANGELO FAHIE, M.S.T.E. and E.

10, Leinster-street, Dublin, 30th June, 1884.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your article on this subject last week you say that the estimate in my letter of 50 per cent. for renewal of lamps per annum seems enormous. It is founded on the ordinary

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notion that 1,000 hours may be counted on as the average life of a lamp in its normal state of incandescence. With 500 hours' use this of course involves the replacement of half the lamps yearly on the average. I heartily endorse your remark that this question of the life of lamps needs elucidation. The only figures with any apparent claim to credit that I have seen tend to confirm the ordinary estimate of 1,000 hours, but the statistics hitherto published are astonishingly meagre. There can be no doubt that much information on this point could be given by the manufacturing companies and by users of lamps, and I venture to ask your support in appealing to them for such exact statistics as they can give. With respect to any one type of lamp, we wish to know not only the average life at the normal brightness, but the average life when the same type of lamp is worked at several grades of candle-power under and over the normal. A mass of information of this kind is needed before we can tell the most economical power at which to work, having regard to the proportion which the cost of renewal of lamps bears to the cost of supply of electrical energy in any given installation. Users of lamps would do electrical engineers a most valuable service if wherever the conditions are favourable—that is to say, wherever the electromotive force is uniform, and the number of hours of use easily counted—they would take the trouble to observe and record systematically, and finally to publish the number of hours each lamp of a given type lasts when exposed to a stated electromotive force. And the value of the observations would be enormously enhanced if in any large installation the lamps were divided into two or more groups, with a known small gradation of electromotive force from group to group.—Yours, &c., J. A. EWING.

University College, Dundee, July 1, 1884.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Setting aside the question of central lighting stations, which even the largest companies shrink from undertaking with their present resources, and under the restrictions laid down by the Board of Trade, the all-important question at the present moment is one of price.

Thanks to the pioneering work done by the companies during the past three years, electric lighting has now taken a firm hold on the mind of the public. It is true that we hear a good deal about the public having lost their confidence in it, but this statement must be accepted in a very limited sense. When a man loses his money in any undertaking he generally loses his confidence as well, and in the present instance the investing public have been very heavy losers.

The objections which were urged against the new illuminant three years ago have become obsolete. The fanciful ones concocted by opponents out of the element of danger are scarcely heard of now; while many practical objections, which were true then, have since been overcome. The ground has been cleared, and there is now no difficulty in convincing a man that the electric light is what he ought to have.

Some correspondence has already appeared in your columns with reference to the present depression and the influence of prices. Much has been said, moreover, as to the cost as compared with gas, and several more or less reliable estimates have been published to show that the one is as cheap as the other.

I think, however, that much of this is quite beside the mark, and that the cost as compared with the old illuminant has not so much to do with the question as has the first cost, the cost of the plant.

My experience goes to show that in most cases people are willing to pay a premium on their gas bills for the sake of having what they are now convinced is a better light, but that they will not face the first outlay for plant.

The field which is open for the electric light is a very wide and varied one, but we may divide it broadly into three, in each of which the conditions are different. (1) We have those to whom the light is either a necessity or a luxury, which they are willing to pay for as such. (2) Those who are willing to buy plant and work the light themselves at a moderate cost. (3) Those who in the nature of things cannot provide or work their own plant.

With the first of these the question of price is not a material one, and there is sufficient work here to keep several firms well employed; indeed, it is among this class that the principal amount of work has already been done.

But the electric light cannot become general till it can provide for the wants of the other two classes as well. Of these the one is principally made up of mills, factories, and workshops, while the other includes shops and private houses.

It is to the former of these we have to look principally at the present moment for our custom, and with them the cost of plant is the one serious consideration. They are willing to buy plant and work the light themselves, but they are unwilling to spend any considerable amount of capital in so doing, and moreover there is a general feeling that in a year or so electrical plant will be very much cheaper. Under these circumstances they will not replace their present gas fittings.

The electric light, it is true, can, even at present prices, compete with gas under equal conditions, but what we want to see, and what we believe can be done, is something more than this. We want to see it taking the place of gas, and this is what it can only do to a very limited extent at present prices.

With regard to the supplying of shops and houses, it may be doubted by some whether any business at all is to be done here until the establishment of central lighting stations.

Though I grant that it cannot become general among this class till the establishment of these stations, yet I submit that there is a very large business to be done here which has not yet been touched.

Many shopkeepers, and also householders, would be willing to purchase a small plant, subject to skilled supervision, but here again they are deterred by the price, and there is the additional difficulty of providing motive power. Gas engines would have found a ready market were they not so frightfully expensive.

This is just the field for the use of secondary or primary batteries. We have heard a good deal lately of various new forms of primary batteries for electric lighting, and there is here an extensive field open for a properly organised company, who will supply the batteries and work them by sending round properly qualified inspectors to attend to the re-charging.

It is of course an open question at the present moment whether this can be done at a price which will induce people to substitute the new light for the old one, but if it can be done anywhere near the price of gas the field is a very extensive one.

I think, therefore, that as long as present prices are maintained operations will be comparatively limited, and, moreover, that if those who are now manufacturing dynamos and other electrical plant insist on maintaining the price, other firms in the engineering trade will take up the manufacture, and turn out apparatus at what is recognised in the trade as a fair price for metal and labour.—Yours, &c.,

W. KINGSLAND.

1, East Parade, Leeds, 1st July, 1884.

THE COMMON SENSE OF ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The worth of legislation for the control of new inventions depends in the long run, not so much on public opinion about them, as on the facts themselves when freed from hope, theory, or surmise.

On the 18th August, 1882, a Bill became law entitled "An Act to *Facilitate* and Regulate the Supply of Electricity." This Act embodies the hopes of the English people, born of gazing on the glitter of the two electric exhibitions held previous to the passage of the Bill, and their fears of having to pay too much for the gratification of these hopes. Three assumptions underlie this Act, the truth of which still awaits confirmation by experience. It was assumed,

1. That the construction of insulated underground systems for conveying electric currents of great strength was understood in the year 1882, and required legislative control in the same sense as railways, docks, or canals require State regulation.

2. That the effectual generation and supply of electricity to a large area from a central station was not only feasible, but commercially practicable.

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3. That the cost of production was known to a nicety, and the conditions of supply so well understood, that the enterprise was sure to be enormously profitable, and therefore fit subject for treatment by way of restriction and penalty.

If these assumptions were not founded on facts, the effect of the Act was either to compel costly experiments under unfavourable conditions, or, by deterring prudent investors from risking capital in an enterprise fettered with impracticable conditions, to postpone *sine die* the time for making a serious experiment on a large scale. The result of two years demonstrates that the restrictions introduced have operated as a complete prohibition of any such experiment.

It is not difficult to show that these assumptions were based on limited experience and on unlimited hope. The experience that exists for laying large insulated cables of copper underground, and for knowing the conditions under which they will remain perfect, is of the slenderest kind now and was almost *nil* then.

When the Bill received the Royal assent, no central generating station existed in England except the experimental station of the Edison Company at Holborn Viaduct.

Again, the Act prescribes conditions in language applicable to a material substance for the sale of something more subtle —viz., a form of energy. The value of energy depends on its capacity for conversion into heat, light, and power. Hence our legislators did not facilitate electric lighting as promised in the title of the Act, when they agreed to clauses preventing companies prescribing particular forms of lamp, such lamps being essential parts of the apparatus required for the conversion of energy into light. Restrictions as to charge would be right and proper when the conditions of production were fully ascertained; but the Act imposed on the companies compulsory supply of light, while leaving them to fight their own battle for the value of the indispensable central site, which value enters as a serious item in the cost of the light.

The inference from this is that the legislative strong meat of 1882 has stunted, if not destroyed, our electrical babe; and that until fostering treatment replaces the ironclad rule of permanent officials, not only the electric light, but the telephone, and every other promising scientific effort will be dwarfed, if not destroyed. The English methods of dealing with great inventions of the nineteenth century will thus be placed in even sharper contrast with those of every other civilised country in the world.—Yours, &c., ARNOLD WHITE.

Devonshire Club, S W.

THE ELECTRIC LIGHTING ACT OF 1882.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last issue you enter at some length into the vexed question of the cost of electric lighting, and hazard the conjecture whether any one will be bold enough to say that the cost of a central electric light station is more than the cost of a central gas station. Twenty-two months ago the Legislature of this country, after careful scientific examination of the then state of the art of distribution of large currents for lighting purposes, arrived at the conclusion that it was in such a complete and advanced condition that the time had arrived for "facilitating and regulating" it according to the title of the Act—that is to say, for laying down stringent conditions under which the novel experiment of distributing electrical energy on a large scale should first be tried. The question of cost and maintenance will therefore to a very large extent be influenced by the legal conditions under which it has to be undertaken. If these conditions are wise and elastic enough to accommodate the uncertain direction of development of the youngest of the arts, your question may not be long in receiving a practical reply. But if these conditions have been based upon a complete misconception of the *differentiæ* which separate the distribution by pipes of a material substance from the first attempts at distribution of energy in the form of electric current by subterranean copper mains, then the interesting question whether the best and cheapest light in every way is obtainable from the combustion of a hydro-carbon or the incandescence of a carbon filament by distributed electricity may, in England at least, be indefinitely delayed. Which of these prevails is easily ascertainable by an examination of the main special provisions of the Act in the light of past and present experience. The general conception of the Act is that of permitting the laying down of a network of conductors under these general conditions. The undertakers have to specify beforehand—in the absence of guarantee as to demand—the area they will cover at first, and the direction in which they will undertake to extend the mains. They are to bind themselves as to price without any limitations *per contra* as to the cost of the ground, for central site, facility of or compulsory purchase for extension, right of way, or security against injunction for nuisance. They are debarred from any selection of customers, on the ground apparently (although a mistaken one) that as electricity is sold by measure customers are all proportionately profitable. They are expressly interdicted from interference with the most important section of the electrical loop, viz., the lamp, and finally they are given 21 years or less within which to achieve practical success and the return of invested capital. To any one who has had practical experience of even small electrical distributions it is only too apparent in every line of this Act that the conditions of commercial success were not understood by those who framed it to "facilitate" the supply of electricity for lighting purposes, and they allowed themselves to be misled by the analogy of the electric main to a gas pipe. But the supply of electric current is not similar to the carriage of stored-up gas. In the one case a form of energy has to be transformed as wanted, and when once the plant has been set up for a given supply the cost of maintenance will not be proportionately affected by variation in actual consumption. In the other case, a material substance is prepared and stored, and if the consumption is less to-day there is more left over for to-morrow without additional cost. Hence the paramount condition of success at the outset is liberty to select customers, so that the hours of burning may be a maximum, and the mains and machinery kept as little idle as possible. Again, in the case of electric supply, the commercial commodity retailed is light, and the apparatus of conversion—viz., the carbon filament—is only a portion of the endless loop of lead and return in which the dissipation of energy in the form of light is made a maximum. Privilege to select for the consumers that form of lamp which is best adapted to the distribution of potential, and is electrically and commercially most economical is an obvious necessity.

Briefly, what is required for any sort of prospect of success is this,

1. Abolition of areas compulsory and permissive, specified streets, &c. The network of conductors must extend as required round the most favourable site previously selected.

2. Free option to pick and choose customers, and to favour long burning hours clients whilst the station is small.

3. Complete control over the lamps used, the undertakers to sell light or power in standard candle hours or horse-power, and the customer to have no perplexity about units of any kind as compared with gas.

4. Freedom from obligation to transfer the property or to do anything at the end of any period which will compel the revenue to be so taxed as to prevent investors from reaping such profits as may be reasonably looked for in pioneer enterprises of this description.

5. Conditions of safety insulation and regulation of pressure to be maintained of course by suitable regulations.

As it stands at present, the Electric Lighting Act of 1882, so far from facilitating electric supply affords the most complete barrier to its introduction, and will continue to do so until repealed. The notion that there was a danger of the upgrowth of a great monopoly is an instance of the danger of premature legislation in advance for difficulties which have not arisen.

Whilst such important questions as those of triple or multiple conductor systems, central station dynamos, meter measurement, and methods of laying mains and feeders are admitted to have scarcely reached their final solution, is it not too much to expect that wise commercial men shall plunge into a new undertaking under conditions which do not give them the very freest scope to feel their way gradually and modify their methods of charge and supply, in proportion as

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industrial invention supplies the means for cheapening the cost and widening the area of practicable distribution. The problem of distributing small electric currents by conductors for the purposes of commercial telegraphy was not solved without much experience; but if the more difficult one of distributing currents a thousand or ten thousand times as strong is to be attempted under the trammels of legislative restrictions, we are not likely to have the opportunity of comparing in England, under equally favourable circumstances, the cost of electric and gas supply.—Yours, &c.,

J. A. Fleming.

20, Coleman-street, E.C.

THE CURRENT-CARRYING CAPACITY OF WIRES.

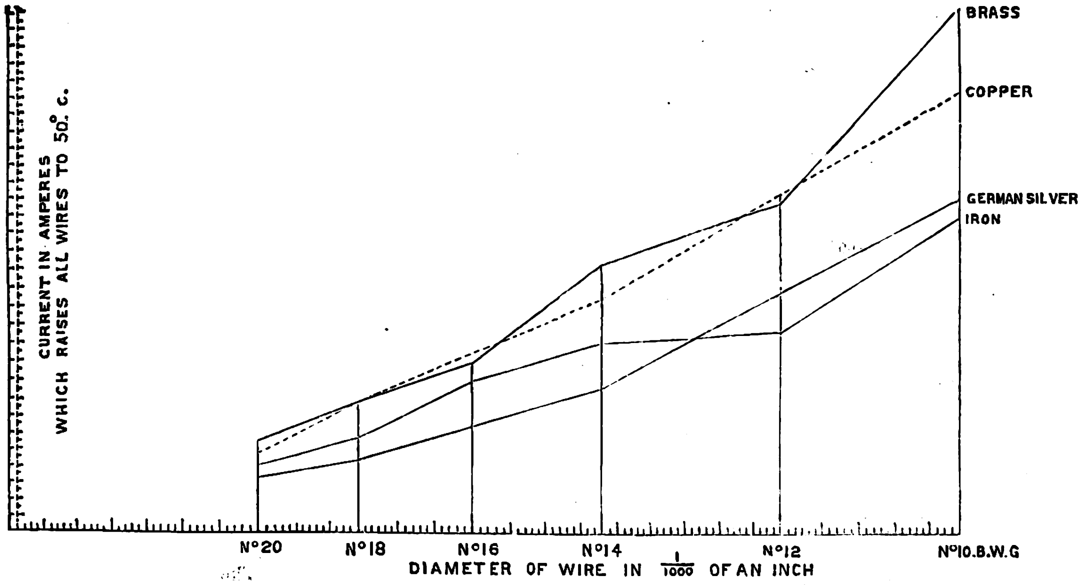
TO THE EDITOR OF THE ELECTRICIAN.

Sir: Your correspondent "Student" asks a question in your last issue relating to a formula quoted from Messrs. Munro and Jamieson's pocket book. This formula purports to give information as to the rise in temperature of a wire carrying a current. It cannot, however, be of any use when obtained, for the reason that the formula in question is not based on accurate physical assumptions. The formula quoted is simply a symbolic expression for the statement that the temperature of a wire becomes stationary when the electrically generated heat balances the heat emitted by radiation in a unit of time, and, as a simple consequence, it follows that for different sized wires of the same metal raised to the same stationary temperature, the square of the heating current ought to vary as the cube of the diameter of the wire.

This result is totally erroneous, and at variance with the result of experiment, and for the reason that the generated heat is removed from a wire insulated in air by *convection* as well as radiation, and in naked wires the former plays the most important part in the dissipation of the energy.

I have recently carried out some experiments on the safe current-carrying capacity of naked wires with just that amount of accuracy sufficient to make the results of practical use without giving them a claim to scientific measurements.

It is necessary to point out that although for different sized wires under given circumstances of atmosphere and enclosure it is possible to obtain a graphic relation between diameter and equi-temperature current, yet the relation is not capable of being expressed as is sometimes done in books by any simple algebraic formula, because, except in the case of conductors wholly buried in homogeneous insulating material of known thermal conductivity, the conditions of heat removal from the wire are too complicated to admit of simple expression; but there are certain cases constantly occurring in practice which it is very useful to have examined. The principal case is that of spiral coils of naked wire insulated in air. Questions of the following description constantly arise:—It is desired to insert in series with an arc lamp a German silver resistance coil, open to the air, capable of carrying safely eight amperes, and having a resistance of four ohms. What sized wire, and what length shall be selected? To provide data for answering the above I had prepared a series of coils of naked wire of German silver, brass, iron, and copper, the sizes of which were Nos. 10, 12, 14, 16, 18, 20 B.W.G. These were coiled in helices on wooden rods, and laid horizontally on a frame. Currents were then sent through them all sufficient to raise every wire to the same temperature, viz., about 50° C., a temperature just bearable to the bare hand. Ample time was allowed to elapse for the temperature to become stationary, and when this was the case the ampere current was recorded in each case. The accompanying diagram records the results of observation. Distances marked off on the horizontal line represent the diameter of the wires in mils. and vertical heights the safe current in amperes. The observations at the stated diameters were marked off, and the points so obtained joined by pieces of straight line. No attempt has been made to "draw a smooth curve by free hand through the points of observation," but the results are given just as obtained. The scale of amperes for the copper is just half that for the iron, brass, and German silver on account of the high conductivity of copper.



Curves showing relation of diameter to safe current.

The results show that the current curve is for the German silver and copper very nearly a straight line; in other words, the current strength which raises different sized wires to the same temperature varies *as the diameter* of the wire within the limits of observation.

A reference to these diagrams is sufficient to give an answer, good for all practical purposes, to the above question. It must be clearly understood that the results in no way apply to the case of covered wires nor to coils other than naked open spirals, insulated and freely open to the air. These results confirm a remark on page 305 of Mr. Sprague's recent excellent book on electricity, that Siemens says experiment shows that safe current varies as diameter simply, and not in the sesquiplicate ratio of diameter. Although from a scientific point of view it would be desirable to carry out experiments of this kind with greater accuracy, yet for all practical purposes the above diagram is sufficiently good—at least, as regards copper and German silver wires. Other useful data could be obtained by taking German silver strip and hoop iron as being frequently used. The introduction into books of formulæ like the one quoted by "Student" may be useful as a material out of which to construct examinations, or "exer-

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cises for the student," but they do not represent the facts of nature, and are of no practical use. All those tables are also erroneous in which the safe current in amperes has been calculated on the assumption of an equal current density in the wire, *i.e.*, an equal number of amperes per square inch of cross section raises different sized wires to the same temperature, because the law of the diameter simply bestows a higher relative carrying capacity upon small wires than upon large. In the above experiments the current sent through the No. 10 copper wire was at the rate of 3,545 amperes per square inch of section, whereas the current passed through the No. 20 wire was at the rate of 8,316 amperes per square inch, and these very different current densities bring the respective naked copper wire spirals to about the same temperature in air.

Professor Forbes has also been led to the conclusion that the safe current varies as the diameter of the wire, and in his interesting paper on the subject he has given an account of an analogous series of experiments leading to the same conclusions.—Yours, &c., J. A. FLEMING.

RUHMKORFF'S COIL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Last week I received a book entitled "The Electric Light in Our Homes," by Mr. Robert Hammond. On page 18 of this book he says:—"On the table is an electrical apparatus known as a Ruhmkorff coil. In my left hand I hold the wire which leads from the positive, and in my right hand the wire which leads from the negative pole of the coil. When the ends of the two wires are kept a short distance apart the current of electricity from the Ruhmkorff coil does not flow, because it is unable to jump over the intervening space in the open air."

Now, sir, I thought that this was one of the "peculiarities" of the induction coil, being able to send a spark through air, but perhaps I am mistaken. If so, would you or some of your readers kindly point out where my mistake lies. With a coil such as is illustrated on page 18 of this book, I should be very chary about taking the - and + wires in my hands, unless the wires were very well insulated.—Yours, &c.,

ROBERT C. JONES.

Moss Bank, George-street North, Dunedin,
Otago, N.Z. May 23rd, 1884.

ALEXANDER BAIN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the churchyard at The Old Aisle, Kirkintulloch, there is a granite block erected to the memory of Alexander Bain, with the following inscription:—

"ALEXANDER BAIN,
Electrician and telegraph engineer, distinguished for many inventions of the greatest value in electric telegraphy, &c., &c.
Born in the Parish of Watten, Caithness-shire, October, 1810.
Died 2nd January, 1876. Interred here."

Alexander Bain died in the year 1877, and I venture to call your attention to the error in the inscription in the hope that it may be corrected.

Bain's versatile inventive faculties will always rank him amongst the greatest of those who, at a very early date, contributed to the development of the electric telegraph, if not of electric science, and it would be unfortunate if such an error as the one I have pointed out should be allowed to remain.—Yours, &c., A. J. FROST.

Society of Telegraph Engineers and
Electricians, June 28, 1884.

ERRATUM.—In the note to Mr. FitzGerald's letter the last formula (for energy) should read $\frac{E^2S}{l}$.

THE LATE SIR WILLIAM SIEMENS.

A meeting was held on Thursday, the 26th of June, in the hall of the Institution of Civil Engineers, Great George-street, Westminster, for the purpose of considering what steps should be taken to raise an Engineer's Memorial to the late Sir William Siemens. The councils—including past presidents and other officers—of five of the leading engineering societies were summoned to attend, namely, in order of foundation:—The Civil Engineers, the Mechanical Engineers, the Naval Architects, the Iron and Steel Institute, and the Telegraph Engineers.

Amongst those present were the following:—Sir Frederick Abel, C.B., F.R.S.; Mr. W. Anderson, Mr. B. Baker, Mr. J. W. Barry, Mr. J. F. Bateman, F.R.S.; Colonel Bateman-Champain, R.E.; Sir J. W. Bazalgette, C.B.; Sir Henry Bessemer, F.R.S.; Sir Frederick Bramwell, F.R.S.; Mr. Brunlees, Mr. E. A. Cowper, Mr. T. R. Crampton, Mr. R. E. Crompton Sir Charles Hutton Gregory, K.C.M.G.; Mr. George Holmes, Dr. Hopkinson, F.R.S.; Mr. J. S. Jeans, Dr. Pole, F.R.S.; the Earl of Ravensworth, Mr. M. F. Roberts, Mr. J. D'A. Samuda, Mr. J. I. Thornycroft, Mr. F. H. Webb, Mr. R. Price Williams, and Mr. Edward Woods.

On the motion of Lord RAVENSWORTH, seconded by Col. BATEMAN-CHAMPAIN, R.E., Sir Joseph Bazalgette, C.B., as president of the senior engineering society—the Institution of Civil Engineers, was asked to preside.

The CHAIRMAN then offered some explanatory remarks, pointing out that a general desire had been expressed among engineers that some memorial should be raised as a recognition of the great merits and important services rendered to engineering by Sir William Siemens; that it had been ascertained it would be agreeable to the authorities of Westminster Abbey that a window should be erected in that building to the memory of the deceased; that possibly the cost of such a window might amount to between £700 and £800; that it was thought the greatest tribute to the memory of the deceased would be by allowing the largest number of contributors, and that under those circumstances it was deemed advisable to limit the subscriptions to one guinea each, such subscriptions only to be received from a member of one of the five societies named.

Sir CHARLES HUTTON GREGORY, K.C.M.G., then moved, and Mr. EDWARD WOODS, V.P. Inst. C.E., seconded, "That this meeting is of opinion that it would be very desirable to commemorate the distinguished character and attainments of the late Sir William Siemens by erecting to his memory a window in Westminster Abbey."

This proposition, having been spoken to by Lord RAVENSWORTH and Colonel BATEMAN-CHAMPAIN, was unanimously agreed to.

On the motion of Mr. E. A. COWPER, seconded by Mr. T. R. CRAMPTON, it was determined to limit the subscriptions in the first instance to £1 1s.

Mr. BATEMAN, F.R.S., then proposed "That an executive committee of three members from each of the five societies, including in every case the president (five to be a quorum, and with power to act), should be appointed."

The following committee was then agreed to:—

For the Civil Engineers—Sir J. W. Bazalgette, C.B. (president), Sir Frederick Bramwell, F.R.S., and Mr. Woods (vice-presidents).

For the Mechanical Engineers—Mr. I. Lowthian Bell, F.R.S. (president); Sir Joseph Whitworth, Bart., F.R.S.; and Sir William Armstrong, C.B., F.R.S. (past presidents).

For the Naval Architects—The Earl of Ravensworth (president), Mr. Samuda (treasurer), and Sir Edward Reed, K.C.B., F.R.S., M.P. (vice-president).

For the Iron and Steel Institute.—Mr. B. Samuelson, M.P., F.R.S. (president), and His Grace the Duke of Devonshire, K.G., and Sir Henry Bessemer, F.R.S. (senior past presidents).

For the Telegraph Engineers—Professor W. G. Adams, F.R.S. (president), Sir William Thomson, LL.D., F.R.S., and Sir Frederick Abel, C.B. (past presidents).

Mr. James Forrest was requested to act as honorary secretary and treasurer to the committee.

The thanks of the meeting were, on the motion of Sir HENRY BESSEMER, seconded by Mr. SAMUDA, unanimously accorded to Sir Joseph Bazalgette for his services in the chair.

THE TELEPHONE AND FIRE.—As showing one of the many advantages of the telephone, it may be mentioned that the first news of the recent fire at the Theatre Royal, Edinbro', was received by its means at the central fire station within a few minutes of the outbreak.

The Superintendent of the Philadelphia Police and Fire-Alarm Telegraph has seized the wires of the Postal Telegraph Company which are strung on the city's poles, on account of failure of the latter company to put them underground by May 1, according to their agreement.

PHSYCHICAL RELEARCH.—According to the *Daily Telegraph* of 3rd inst. the Phsychical Research Society now numbers amongst its members such well-known electricians as Lord Rayleigh, who is its vice-president, Professors Adams, Balfour Stewart, Schuster, Lodge, and Barrett.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 *p.m.*

CONTENTS.

Notes 169
Electro-Chemistry. By Dr. G. Gore. (Continued) 174
Correspondence—
The Cost of Electric Lighting 175
The Common Sense of Electric Lighting 176
The Electric Light Act of 1882 177
The Current-Carrying Capacity of Wires. Illustrated 178
Ruhmkorff's Coil 179
Alexander Bain 179
The Late Sir William Siemens 179
The Electric Lighting Act 180
Finsbury Technical College. Illustrated 181
City and Guilds of London Institute 182
Primary Batteries for Electric Lighting. By I. Probert. Illustrated 183
William Sturgeon 186
Legal 190
The Inventors' Institute 192
Companies' Share List 192
Telegraph Traffic Receipts for June, 1884 192

E. W. LANCASTER.—*A letter awaits you.*

THE ELECTRIC LIGHTING ACT.

Our last week's leading article has attracted more attention than we had any reason to expect at the time, and has reopened a question which for a good while past we have been content to let remain closed. We have expressed our opinion so openly and so often on the Electric Lighting Act of 1882 that we can hardly add anything to what we have already urged in objection to it. Time and experience, however, are daily confirming the worst we have said about that mischievious measure, and the subject is now, it seems to us, ripe for action of a more practical kind than mere criticism. From among our correspondence this week touching our remarks on the cost of electric lighting we select two important letters for publication —one from Mr. Arnold White and the other from Dr. J. A. Fleming. Both these writers are known to be deeply interested in the welfare of electric lighting; their letters prove conclusively that they have given careful thought to the subject, and their testimony as to the several causes of the failure of the Act is as trustworthy as any that could be had. We earnestly draw the attention of our readers to these letters, and invite further expressions of opinion, the result either of practical experiment or of local information as touching the municipal interests involved.

From the very first we deprecated the introduction of any Act of Parliament regulating the operations of electric lighting promoters, and we maintained all along that opposition to it should take the form, not of amending its clauses, but of getting it rejected. Long before now the well-meaning but short-sighted supporters of Mr. Chamberlain's Bill have, we should imagine, discovered their mistake. It was useless to seek better terms in a measure whose radical principle was to prevent any terms whatsoever under its provisions being helpful to the system it pretended to regulate. Had it been deliberately drawn up in the interests of the gas companies it could not have been more inimical to the interests of electric lighting companies. The wide-spread ruin which has overtaken these latter is proof that they have profited nothing by the Act, and the fact that there have been virtually, and almost literally, no installations of the electric light under its provisions is proof that nobody could have profited by it even if the attempt had been made. Our best wishes go with the one or two ventures which are being hazarded in spite of the Act; but it is manifest that in the particular circumstances, if they escape failure it will be due to a very liberal interpretation of the clauses of the Act, and not by virtue of any liberality to be found in it. We stated at the time that the Bill was framed in a hostile spirit, though professedly introduced to give legislative encouragement to the new light. It was the sort of legislative encouragement Protectionists give to imports by elaborately benevolent fiscal dues.

But even if we grant that the apparently selfish objects were absent from the minds of the framers of the Act, the fact remains that in practice it has operated as a complete barrier to the introduction of electric lighting, and has therefore failed in its object, if its object was really friendly. The attempt to regulate what nobody—not even experts—thoroughly understood was bound to break down, and no sort of legislation in that direction will ever succeed until electric lighting business has had an opportunity of working in absolute freedom from legislative control. If the great gas purveyors had been saddled with any such conditions as those which have been imposed on the purveyors of electric light at the very outset, there would probably now be no gas supply; yet the problems of gas lighting were never so obscure or so intricate as those which surround the generation and distribution of electricity. The Bill treated the commodity as if it were all cut and dried, and had only to be sold across the counter. As a matter of fact it is in a crude condition still, and must remain so until experiments, and these on the most varied and extended scale, have been tried. It was assumed, as one of our correspondents puts it, that the cost of production was known to a nicety, and the conditions of supply so well understood that they were sure to be enormously profitable; whereas it is still a moot point whether, under any conditions whatever except those of their own choosing, the undertakers of electric lighting could make any profit at all. The conditions required even for possible success are carefully set forth by both our correspondents, and they are in agreement as to what is now needed. There must be freedom to choose their own areas for operation, to choose their customers, to supply what lights they and their several customers may agree upon, and to be exempted from what may justly be called the confiscatory clauses of the Act. To our thinking these propositions mean nothing short of the unconditional repeal of the obstructive part of the

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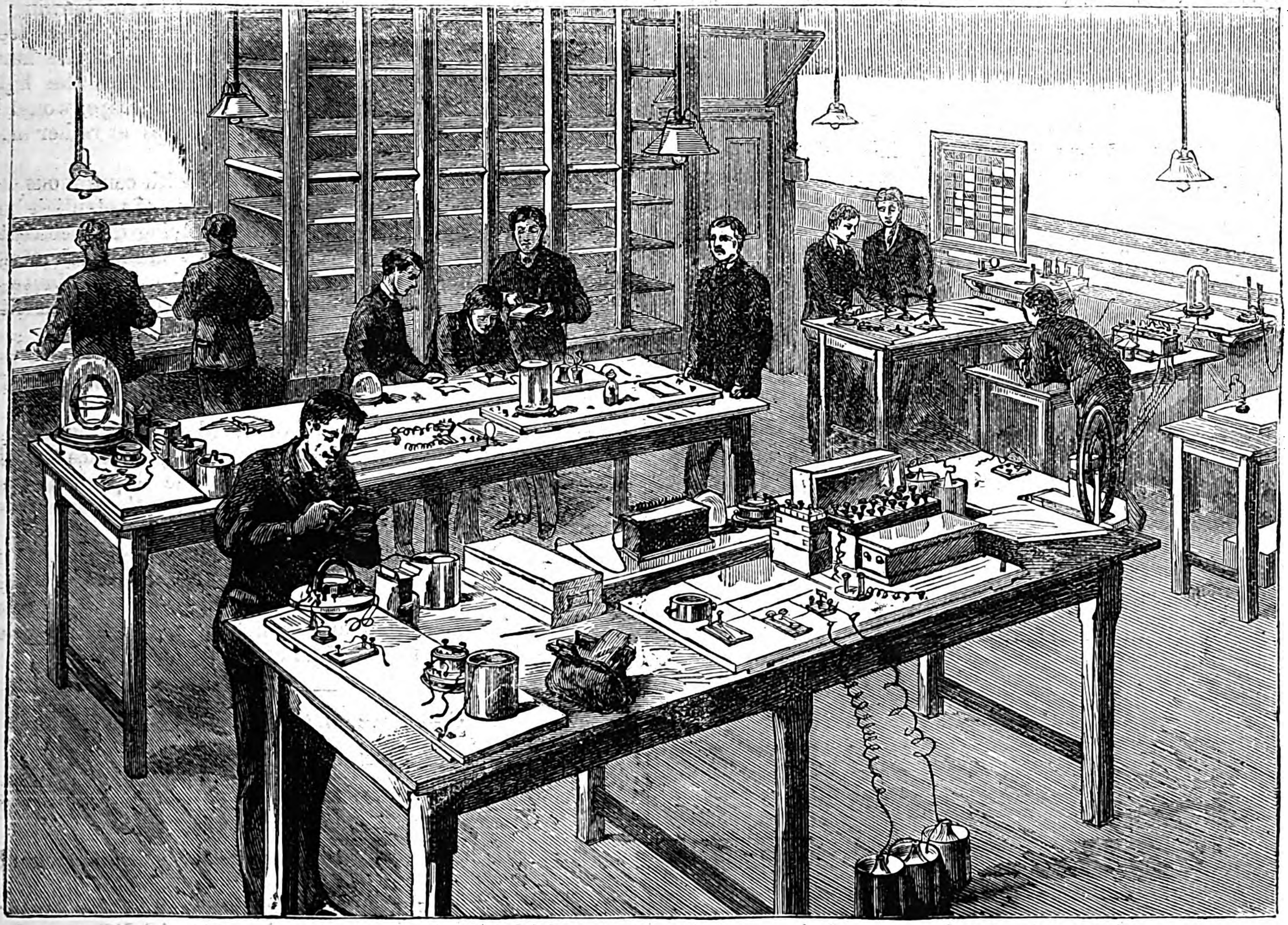
Bill; and to that end we unhesitatingly recommend our clients to move, leaving of course intact such regulations as may be necessary for the safety of the public and the rights of municipal authorities. It is not to be expected that Electric Lighting undertakers will carry on a purely experimental game for the benefit of the public; nor do the public expect it of them. Let, therefore, the advantages of the electric light be preached far and wide; but let it be known at the same time that the prohibitory enactments of the Electric Lighting Act alone prevent the general spread of those advantages.

FINSBURY TECHNICAL COLLEGE.

In a note in last week's issue we referred to a pamphlet describing the work of the City and Guilds Institute, which had been written for the opening of the Central Institution, in Kensington, an event which we also recorded in the same note. We ascribed to Prof. Ayrton the authorship of this pamphlet, but find that it was written by Mr. Philip Magnus. We now give an extract from this little compilation, which details the work done at the Technical College, Finsbury, E.C., and at the same time publish an illustration of one of the laboratories at that college, which we think will interest our readers.

Less than two years after the foundation stone was laid, the new college in Tabernacle-row was opened. The building was erected by Messrs. Peto Brothers, from designs furnished by the architect, Mr. E. N. Clifton, under whose direction it was completed. Including the expense of fitting and furnishing the laboratories and workshops, the building has cost over £35,000, towards which sum the Drapers' Company contributed £10,000. The structure is very simple, without ornamentation of any kind. It consists of three stories besides the basement. On the ground floor to the left of the entrance are two rooms belonging to the Physical Department, under the direction of Professor Ayrton, used for delicate measuring experiments in telegraphy, &c. In the rear, looking into the playground of the Cowper-street schools, is a large room used for brewing and for experiments requiring the use of steam in organic chemistry; and adjoining this room is a physical laboratory, for experiments in heat. A small class room for general purposes, and a workshop for the preparation of physical instruments are on the same floor. The staircase is in the centre of the building, and lighted from the top, and is surrounded on all sides by class rooms and laboratories. On the first floor are two lecture rooms, each capable of accommodating 200 students—one being used mainly for lectures in chemistry, and the other for lectures in physics and mechanics.



Finsbury Technical College. One of the Laboratories for First Year's Electrical Engineering Students.*

The physical lecture room communicates with a large and lofty museum of physical apparatus, and adjoining this are two other laboratories. These rooms are arranged for the carrying on of an organised series of experiments in current and in statical electricity. The peculiarity of the method adopted is that each experiment has all the apparatus required for performing it ready in position, together with printed instructions. The students work in groups of three, as shown in the engraving. The instruments needed for each experiment are mounted on a board, which can be taken to the lecture room for use during the lecture. Examples of such arrangements of apparatus are now on view in the exhibition. Adjoining these rooms is a small apartment fitted up with drawing tables, in which the students plot out curves, and record the results of their experiments on squared paper. The second floor is

* We are indebted to Mr. Magnus for the oan of this illustration.

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mainly occupied by the chemical laboratories. The main laboratory has ninety-six working places, each of which has two drawers and two cupboards, and is available for two students working at different times. Each bench is covered with a hood, at the top of which are openings at intervals connected with the chimney, in which a draft is produced by the waste heat from the boilers, the flues passing down the benches and along the floor. The laboratory is divided by double glass screens, between which are the arrangements for the supply of sulphuretted hydrogen for the use of students. Plans of the laboratory fittings are exhibited in the corridors of the second floor of the Central Institution. Besides the professors' and assistants' rooms, there is a class room, a balance room, two store rooms, and a laboratory for advanced students on the same floor. The instruction, which is under the direction of Professor Armstrong, and will remain under his charge until the opening of the Central Institution in January next, is somewhat different from that of most chemical schools, the object in view being to teach the main facts and principles of chemistry, and to lead the students to observe correctly, and to reason from experiment, rather than to make them highly proficient analysts. Indeed, the teaching of analysis as in ordinary schools is a very unimportant feature in the earlier part of the course.

In the basement of the building is a large room which contains dynamo machines, worked either by the main steam engine or by the gas engine in the same room. The greater part of the building is lighted by incandescent lamps, which are supplied with a current from an Edison dynamo machine in this room. Another room in the basement is fitted up as a mechanical laboratory, under the direction of Professor Perry, who at present has charge of the instruction in engineering and in mathematics. The apparatus in this laboratory is nearly all of a novel kind. Among other experiments are those on the energy of a rotating body, the resistance of wire to extension and torsion, and of beams loaded and supported in various ways, and of the vibration of the pendulum, &c. Some of the apparatus used in these experiments, portions of which have been made in the school itself, are now on view in the Central Institution. Adjoining this laboratory are two workshops—one fitted with benches and lathes for woodwork, and the other with vices and machine tools. These workshops are in charge of a practical mechanic, and the students are able to construct models and machines for their own use and for the use of the college. There is also an engine room containing a boiler and steam engine, which are provided with appliances for measuring evaporation, steam temperatures, steam pres-

CITY AND GUILDS OF LONDON INSTITUTE.

The following questions were set at the recent examinations for students who wished to pass in the Honours Grade. The Ordinary Grade papers 22 B and 22 C will be found in last week's issue :—

PAPER 22 B.—*Electric Lighting and Transmission of Power.*

HONOURS GRADE.

[*Candidates are not to answer more than one out of the first three questions, and not more than seven altogether.*]

Questions 1, 2, and 3 are the same as in the ordinary grade paper.

4. A, B, and C are three points, each at a distance of 157 yards from the next; at A there is a dynamo; at B a group of 200 incandescent lamps requiring 110 volts and 0·75 ampere each; and at C a group of 250 lamps requiring 100 volts and 0·83 ampere each. Calculate the diameter of the copper conductor that must be used for the going and return wires between A and B and between B and C respectively if the potential difference maintained at the terminals of the dynamo is 112 volts. One yard of commercial copper wire one square inch in section has ·00002435 ohm resistance.

5. Show that when a number of houses are supplied with electricity in *series* it is possible to make the supply of electric energy given to any one house *absolutely constant* and independent of the amount consumed by the other houses. Describe, with drawings, the simplest method that could be practically adopted for fulfilling this object if there be no special restriction as to the potential of the main at any point.

Show that by no known system can this result be absolutely attained if the houses be supplied with electricity in *parallel*. Give, however, the details, and illustrate by drawings the method you would adopt for making the supply to each of the houses in parallel as nearly as possible independent of the consumption on the rest of the circuit.

6. Describe in detail the various systems that have been devised for *economically* supplying electric energy to a large district of houses without the potential in any one house being made to exceed that of the earth by, say, 150 volts. Which of these systems would you practically adopt, and why?

7. Explain fully what are the various causes of loss of power in an electro-motor, and how each kind of loss may be practically diminished.

8. Explain why the efficiency of an incandescent lamp is increased by sending a large current through it, while its life is diminished. The life of good incandescent lamps burning at their normal power is said to be 1,000 hours. Show from your own experience whether the *economical use* of the lamp, taking into account energy consumed to produce the light, together witth the cost of renewals of broken lamps, would be increased or diminished by burning the lamps at rather more than their normal candle-power.

9. An electric railway is to be worked with continuous currents. Give a table showing what difference of potentials you would allow between the conductors supplying the electricity, taking into account the number of segments on the commutator of the dynamo and the number of revolutions per minute of the armature, so that the conductors supplying the electricity, if touched by passers by, should not be dangerous.

10. Explain in detail the experiments you would carry out to determine the efficiency of a dynamo and the efficiency of a motor.

11. A dynamo is to be placed on board ship. What type of dynamo would you select, and how would you place it relatively to the ship so that the rolling of the ship should produce least strain on the bearings of the rotating armature? Give full reasons for your answer.

12. Explain why an electric light is less penetrating in foggy weather than a gas light of the same intensity. What methods would you adopt for making the electric light more penetrating? What standard of light would you use when measuring the illumination of an arc lamp, and why?

22 C.—*Electrical Instrument Making.*

HONOURS GRADE.

[*Candidates are not to answer more than one out of the first three questions, and not more than seven altogether.*]

Questions 1, 2, and 3 are the same as in the ordinary grade paper.

4. Explain why change of temperature alters the constant of an instrument used for measuring potential difference, but does not affect the readings of an instrument used for measuring current. How may the error in the former instrument, arising from the change of temperature from day to day, be automatically entirely compensated for? Will such a method of compensation compensate for the error arising from the heating of the coils by the passage of the current?

5. In making a galvanometer for measuring potential difference, consider whether it is better to put all the resistance on the bobbin or to wind the galvanometer with a lower resistance and employ an auxiliary resistance coil. Of what material would you make the wire wound on the galvanometer bobbin so that the error arising from the heating of the bobbin by the passage of the current should be a minimum?

6. Calculate the weight, length, and resistance, at 15°C., of a copper wire one-tenth inch thick, and having 95 per cent. conductivity used in coiling an electro-magnet, the dimensions

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of which are:—Distance between end cheeks 15in., external diameter 5in., and internal diameter 3in. Specific gravity of copper 8·9. Weight of a cubic foot of water 62·4lb. Resistance, at 0°C., of one foot of pure copper wire $\frac{1}{1000}$ of an inch in diameter 9·718 ohms, and change of resistance per degree centigrade 0·388 per cent.

7. When the external dimensions of the bobbin of an electromagnet are fixed, prove what should be the diameter of the iron core compared with that of the bobbin—first, for weak currents; second, for strong currents. Prove also that the same proportion of diameter of bobbin to diameter of iron core does not hold when it is the diameter of the core that is fixed, and that of the bobbin variable.

8. What is the rule for determining the best resistance of wire to wind on a galvanometer to be used with a Wheatstone bridge? Apply it to the case where the proportional coils are 100 and 1,000 respectively, the third known coil 7,500 and the unknown consequently about 750. Does it follow that a galvanometer having the resistance which you have just calculated must necessarily be more sensitive for the particular resistances on the bridge above stated than any other kind of galvanometer having a totally different resistance?

9. You are desired to ascertain the value of the deflection of a galvanometer absolutely in amperes. Describe in detail the method you would adopt, and the exact precautions you would employ to secure accuracy in your result.

10. Describe fully in detail the best method of adjusting resistance coils of low resistance. Give a drawing of a good *sliding* contact to be used with resistance coils. Describe the principle and the construction of Thomson and Varley's double sliding resistance coils.

11. What is an "artificial submarine cable?" How exactly is it made, adjusted, and tested, and what is its use?

12. Describe fully the fitting-up of a telephone exchange, giving drawings of the details.

PRIMARY BATTERIES FOR ELECTRIC LIGHTING.*

BY ISAAC PROBERT.

(CONCLUDED FROM PAGE 163.)

Let us examine the point last referred to a little in detail. Both in a voltaic battery and in a dynamo-electric machine the electric energy is ultimately referable to combustion, or, more strictly, to chemical combination. In each there is a combustible substance, oxygen or an equivalent substance, to sustain the combustion, and the means wherewith to collect and utilise the energy liberated. In a voltaic battery, the combustible substance is usually zinc, and the oxygenous substance sulphuric acid. In a dynamo-electric machine—or rather in the furnace of the engine that drives it—the combustible substance is coal, and the oxygenous substance air. The question, therefore, as ordinarily presented, resolves itself into this:—Required a certain quantity of electric energy; can it be more economically produced by burning zinc in sulphuric acid in a voltaic battery, or by burning coal in air in the furnace of the engine of a dynamo-electric machine? In answering this question, we must consider the relative cost of zinc and coal, their thermal equivalents—that is, the amounts of heat obtainable by the combustion of equal weights of the two materials; the efficiency of the battery and the engine and machine—that is, the proportion of useful work obtained to the total energy generated; the cost of the oxidant of the zinc-air, the oxidant of the coal, costing nothing; the relative cost, both original and for maintenance, of the battery and the dynamo and engine; and the relative cost of attendance. In the case of the battery there is also the possibility of the utilisation of the bye-products to be considered.

To make the matter quite clear let a practical illustration be taken. Let it be supposed that a house has to be lighted by a hundred incandescence lamps, each requiring a current of ·75 of an ampere urged by an electromotive force of 100 volts. The rate at which energy is expended in each lamp, expressed in volt-amperes or watts, of which 746 are equal to a horse-power, will be ·75 × 100, that is 75. The energy expended in the 100 lamps will be at the rate of 7,500 watts, which are equal to 10·05 horse-power. But this, it must be remembered, is the actual rate at which energy is expended in the lamps. The energy that has to be developed by the engine is greater, for no dynamo-electric machine is perfectly efficient, no dynamo machine gives out as electrical energy the exact equivalent of the mechanical energy expended upon it. Let it be supposed that the machine used in our installation has a "commercial efficiency" of 80 per cent.—that is, that 80 per cent. of the mechanical energy put into the machine reappears in the external or lamp circuit as electrical energy, the balance being wasted in heating the armature coils, and the friction of axles, slipping of belts, and other mechanical sources of loss. Then the rate at which energy is generated by the steam engine must be 10·05 × 1·25, that is 12·55 horse-power. This mechanical energy is to be produced by the combustion of coal, and if all the heat liberated in the combustion of the coal could be collected and utilised, the supply of coal required to generate energy at the rate of 12·55 horse-power would be very small; but, unfortunately, steam engines, even of the best make, have but low efficiency, and a horse-power hour of energy requires in practice somewhere about 4½ lbs. of coal for its production; 12·55 horse-power-hours will therefore require about 56½ lbs. of coal—say, roughly, half a hundredweight, the cost of which is not more than 6d. Assuming that the lamps were required to burn for 1,800 hours a year—that is, on an average, nearly five hours a day—the annual cost for coal would be £45. The prime cost of a suitable dynamo machine and engine (with boiler) would be, say, £300, the interest on which, at 4 per cent., would be £12, and the annual depreciation, at 10 per cent., £30; the cost of attendance would be about £60, so that the prime cost would be £300, and the total annual cost £147, or £1 9s. 5d. per lamp.

If a galvanic battery is used to supply the current to the lamps, the energy will require to be produced at a rate of somewhere between 10·05 and 20·1 horse-power, for the efficiency of a galvanic battery depends upon the relation subsisting between the resistance of the battery itself and the resistance of the external circuit. When the greater resistance is reduced until it exactly equals the smaller, the greatest possible current is obtained from the battery, but exactly one-half of the energy liberated is wasted in heating the battery. When the external resistance is high, as compared with the internal, the current is less, but the percentage loss of energy is also less. As a matter of practice, therefore, it becomes advisable to arrange the resistances so that the external is greater than the internal, whereby the efficiency of the battery is made to as nearly approach a hundred per cent. as we wish. Let it be supposed that in our installation the efficiency is, as in the dynamo just considered, 80 per cent. To liberate a horse-power-hour of energy, a quantity of zinc must be oxidised equal to 2·022 lbs. divided by the electromotive force of the galvanic couple in use. It is calculable that the highest electromotive force obtainable in any zinc sulphuric acid battery is 2·248 volts, from which, however, a deduction must be made on account of the energy absorbed in the chemical action of depolarisation. The amount of the deduction will depend upon the nature of the depolariser. With nitrate of soda and sulphuric acid it is ·708 volt, with bichromate of potash it is ·343 volt, and with fuming nitric acid ·284 volt. In order to do fullest justice to batteries, let it be assumed that strong nitric acid is the depolariser used in our installation. The deduction to be made from the total electromotive force of the battery is therefore ·284 volt, and the net electromotive of the battery is 1·964 volt, which corresponds to a consumption of 1·03 lb. of zinc per horse-power-hour of energy. To liberate 12·55 horse-power-hours, 12·93 lbs.—say 13 lbs.—of zinc must be used. If the price of zinc be taken at 2½d. per lb., the zinc used per hour costs 2s. 8¼d. But the expense does not end here. Air, the oxidant of coal, costs nothing; whereas sulphuric acid, the usual oxidant of zinc, is of considerable value, costing, even on the commercial scale, ¾d. per lb.

To oxidise a pound of zinc 1½ lb. of sulphuric acid is required, as is shown by the equation, $Zn + H_2SO_4 = ZnSO_4$

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* Paper read before the Society of Arts, May 28, 1884.

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$+ H_2$. To oxidise 13 lbs. of zinc, 19½ lbs. of acid are therefore required, which costs 1s. 2⅝d.; this added to the cost of the zinc, makes about 3s. 11d. But we cannot stop even here. In order that the zinc may give the greatest possible return of energy, the electromotive force of the voltaic arrangement must, as has been stated, be high, and this—as a net result, at least—can only be obtained by the aid of a good depolarising liquid. We assumed ourselves to be using strong nitric acid, and if we suppose that the average effect of nascent hydrogen upon this substance is to produce nitric oxide (N_2O_2), the amount of acid required will be shown by the equation, $2HNO_3 + 3H_2$ (equivalent to 3Zn) $= N_2O_2 + 4H_2O$. It follows, therefore, that the solution of every pound of zinc is accompanied by the deoxidation of ⅔ lb. of nitric acid. In the production of 12·55 horse-power-hours of energy, 8⅔ lbs. of nitric acid will therefore be deoxidised, the cost of which, at 6d. per lb., is 4s. 4d. This, added to the cost of zinc and sulphuric acid, gives 8s. 3d. as the total cost of materials.

But we have not yet done. A battery cannot be charged, and then kept in action until every grain of zinc and every drop of acid have been consumed. It has been found by experience that no more than about 20 per cent. of the acid can be utilised. When this proportion has been used, the battery begins to flag, and is soon of no further use for electric lighting until the solution has been changed. The greater part of the acid is thus removed as spent solution. But neglecting this source of waste for the moment, and assuming that by a careful process of "refreshing," it is possible to completely exhaust the acid solution, let us see what the cost of our 10·05 horse-power is when generated by a galvanic battery. We have seen that the cost of materials per hour is 8s. 3d., and assuming, as before, that the light will be required for 1,800 hours a year, the annual cost for materials only is £742 10s. 0d. The prime cost of the battery may be taken at £120, the interest, at 4 per cent., on which is, say, £5, and the annual depreciation at 10 per cent. is £12. The cost of attendance is very difficult to determine. Primary batteries have as yet been used for electric lighting to such a small extent that there are, practically, no records of experience whereon to base an opinion. It is claimed by the inventors of batteries that the cost is very small; they say that no skilled attendance is required, and this seems reasonable; and that there is nothing further to do than might be done by a domestic servant in the ordinary course of his duties. Let us assume that this is so, and that the cost of attendance is so small as to be negligible.

If we divide the total annual cost (that is £759 10s.) by the number of lamps, the annual cost per lamp is found to be £7 11s. 8d., as against £1 9s. 5d., when a dynamo machine is used. The difference is great, but it becomes even greater when we remember that it is never possible to completely use the acid solution.

From what has been said, it will be gathered that, in a comparatively large installation such as has been sketched, primary batteries have little chance of success; but for smaller installations of, say, ten to twenty lamps, there may, perhaps, be a field of action open to them. Few people occupying a house requiring so few lamps as this would incur the trouble of a dynamo and engine, although for health's sake they might not object to the cost of the light as produced by a battery.

In what way is it possible to reduce the cost of electric lighting by galvanic batteries? It is evident that there are four ways open; and invention has been active in all. In the first place, a cheaper oxidisable substance than zinc may be employed; and in the second, possibly a cheaper oxidant than sulphuric acid. Next, contrivances may be adopted by which the solutions are more completely exhausted; and lastly, the bye-products—the substances formed during the action of the battery—may be utilised in the arts.

In the first place, as to the oxidisable substance:—Zinc is almost universally employed, but lead and iron have been suggested, and a battery using the latter substance is now before the public.

Next, as to the oxidant, or speaking more generally, the solvent of the positive element of the cell:—Sulphuric acid has been replaced, among other substances, by hydrochloric acid, and a battery employing this liquid has been introduced by Mr. Ross.

As to the bye-products, little can be said, except that the less said the better. Some promoters of patent batteries make a great point of the value of the bye-products of their batteries, but, as a matter of fact, their statements on this point will seldom bear investigation. A zinc residue contains a certain percentage of the metal in a state of chemical combination, from which it has to be recovered by a somewhat costly process, and one hardly likely to afford any profit to the person using the battery.

It may be interesting to notice that, in the Telegraph Department of the Post Office, no residues are thought worth preserving, except the "black mud" (technically so-called) from the Daniell cells, which contains a very large percentage of pure copper in the metallic state. Last year there were 69,323 Daniell cells in use, and the sum realised by the sale of the year's "black mud" was £167 14s., or rather more than a halfpenny per cell per year. An idea may be formed from these figures of the magnitude of the sum likely to result from the sale of the zinc residues—which in the Post Office are thrown away as worthless—in the case of an ordinary householder using some ten or twenty cells.

During the past few years, several batteries especially designed for use in electric lighting have been devised, and the inventors of the more important have been good enough to bring their batteries here to-night, or to furnish descriptions of them. These batteries may be divided into two classes; those in which the liquids are kept in motion, and those in which they are allowed to remain in a state of quiesence. Of the latter, one of the most important is that devised by Messrs. Holmes and Burke. A description which these gentlemen have been good enough to furnish reads thus:—

"Each battery of eight cells can be charged or discharged at two operations, by means of a system of syphons formed partly in the substance of the outside cells. In order to charge the battery it is only necessary to fill a wooden measuring vessel with the exact quantity of fluid necessary to run into the battery, to connect this vessel with the long leg of one of the syphon systems, and to raise the vessel to a certain height, when the liquid immediately distributes itself amongst the cells, and is bound to attain a uniform height in each of them. To discharge the battery, it is only necessary to reverse the process.

"The fumes are collected and suppressed. The porous pots are sealed into wooden covers, which contain passages for the escape of fumes. The passages communicate with one main pipe formed in the substance of the cells, and the fumes can thence be led away to the fume box, where they are either dissolved, or chemically absorbed, according to circumstances.

"The connections between the cells are so simple that they never can be coupled up wrongly, and they are placed beyond the reach of injury by acids or fumes. They never require disconnection when the battery is discharged or re-charged. They require partial disconnection when the plates have to be amalgamated, but the latter, when once thoroughly amalgamated, hardly ever require re-touching. Plates have been run for two months without re-amalgamation.

"The depolarising liquid is cheap and easily handled. It is made of nitrate of soda dissolved in solution of sulphuric acid of a particular strength. It depends for its action on the formation by the current of nitric acid in the porous pot. The hydrogen entering decomposes the nitrate of soda by the aid of the acid, forming sulphate of soda and nitric acid. The liquid is of good conductivity, and as the nitric acid is only formed as it is wanted, the inconvenience of handling this very disagreeable acid is avoided.

"The cost of the liquid is only 5½d. to 6d. a gallon. Each gallon furnishes from 750 to 800 ampere-hours of electricity at an electromotive force of 1·92 volt—*i.e.*, about 1,536 watts, or very nearly two hour horse-power.

"The internal resistance of the battery is very low for a primary cell, and equals ·02 ohm as nearly as possible."

It may be added that, like the generality of electric lighting

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batteries, the batteries of Messrs. Holmes and Burke employ carbon and zinc as the elements.

The battery which next claims attention is that of Mr. O. C. D. Ross, of which a model is on the table. The chief point of novelty distinguishing it is the ingenious arrangement for charging and discharging the depolarising liquid.

The battery itself is enclosed in a box, about 1 ft. square by 7 ft. long, which contains thirteen double cells, the plates in each of which weigh about 10 lbs.; the whole box when charged weighs about 2 cwt. Each cell contains two carbon plates (formed of ½-in. carbon rods placed side by side), which are immersed in dilute hydrochloric acid mixed with one-sixth of its bulk of a mysterious compound called by Mr. Ross "Eureka," but which might doubtless be replaced, without materially affecting the action or the cost of the battery, by nitric acid. The zinc plates dip into a solution of common salt, the liquids being kept apart by porous partitions. The mechanical arrangement by which the carbon cells are filled and emptied is very simple; a horizontal pipe connected by flexible tubes to the bottom of each inner cell is raised or lowered; one end is attached by a flexible tube to a cask of acid, and the other end is led to a waste tank. When the horizontal pipe is raised, and communication with the waste tank cut off, the acid flows, on turning the tap of the acid cask, into the inner cells. When spent liquid is required to be removed, the horizontal pipe is lowered, and the liquid flows from the cells to the waste tank. The outer cells are filled with a solution of salt in one operation, by pouring the solution into a groove extending the whole length of the box, and connected by side passages with the cells.

The Ross battery has been examined by Dr. Hopkinson, who reports that:—

"Comparing this battery with others, a great deal may be said in its favour.

"Its constancy with a large current is remarkably good.

"The liquids used in the cells are less expensive than in any battery having any pretence to constancy.

"Mr. Ross's method of drawing off and replenishing the liquid is very convenient."

The electromotive force per cell is stated to be 1·82 volt, and the resistance 0·06 ohm.

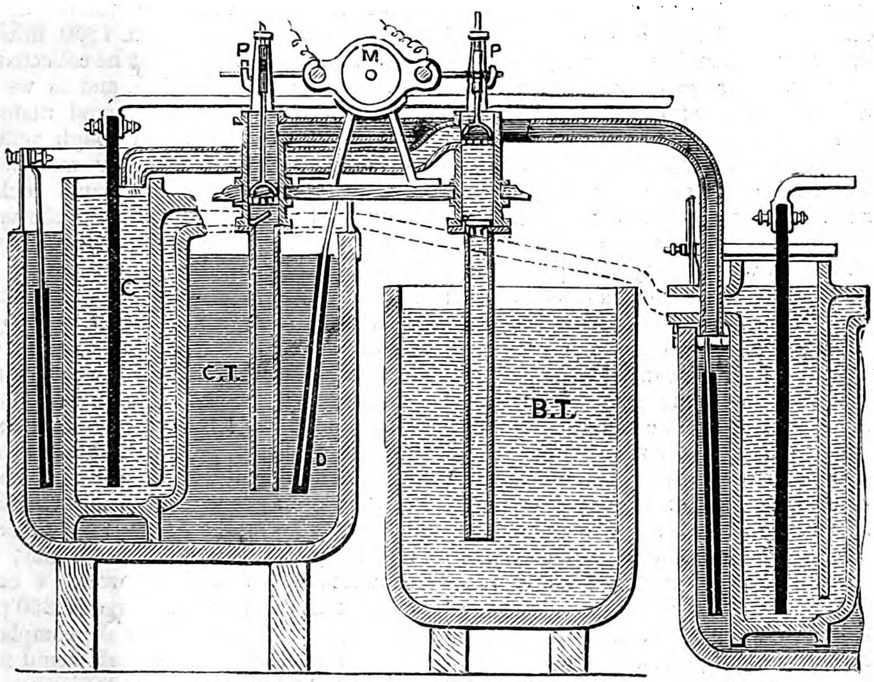
Another battery, introduced some time back, is that known as the "Edco" or "Heap" battery. It is a carbon-zinc couple using bichromate of potash as the depolariser, and dilute sulphuric acid as the excitant. The cells are lined with lead, and hold each 1½ gallon of the bichromate mixture (which can be purchased ready prepared at 1s. per gallon). The zinc plates are 10 by 6 inches, and so offer a total surface of 120 square inches to the action of the acid; they weigh 3 lbs. each. The electromotive force is stated to be 2 volts per cell, and the resistance 0·2 ohm. The point of novelty is claimed to lie in the preparation of the bichromate solution, the description of which is best given in the manufacturers' own words. They are as follow:—

"In each lead cell pour six pints of water, and in each repeat the following operation:

"Fill the colander (which is supplied with the battery) with bichromate of potash, and hang it in the cell so that the crystals are just immersed in the water. Pour about one-fourth of three pounds of sulphuric acid over the crystals in the colander slowly, stopping occasionally when the liquid boils. As fast as the bichromate of potash gets dissolved, add more, and continue pouring in sulphuric acid as before, until there are used up for each cell all of one and a-half pounds of bichromate of potash, and three pounds of sulphuric acid. When the liquid is entirely cool, it is ready for use. . . . . This fluid will last twice as long as the . . . . fluid ordinarily supplied."

Mr. Heap is good enough to exhibit a three-cell battery in action to-night.

In the other or circulating class of batteries, there is one deserving of notice. It is the invention of Messrs. Oliphant, Burr, and Gowan. It is a two-fluid bichromate battery, having zincs coated with an extremely thin film of gold before amalgamation. The exciting liquid is a solution of salts of mercury. The liquids for the outer jars and inner porous pots are pumped out of separate tanks into distinct pipes communicating with the first jar and the first porous pot. They then rise up syphon pipes into the adjoining cell, and flow onwards in this way through the whole series. To avoid any possible stoppage through friction in the pipes, it is advisable to have the first cell one-twelfth of an inch higher than the second, and so on. Thus, in a series of 36 cells, the last cell will be three inches lower than the first. The last jar and porous pot are connected to their respective tanks. The tank holding the bichromate solution is fitted as a cell, and works a Griscom or other motor, which causes two small pumps to keep the liquids in constant circulation.



Oliphant, Burr, and Gowan's Battery.

C T Chloride Tank.
B T Bichromate Tank.
P P Pumps.
M Motor.
C Carbon.
D Gold Coated Zincs.

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The pumps raise two cubic inches of liquid per stroke, and work at the rate of thirty strokes per minute. The pumps are constantly at work day and night, whether the battery is in use or not.

The effect of gilding the zincs before amalgamation is, it is stated, to materially decrease local action.

Many other batteries might be described, and it may be interesting to note that, during the past three years, about 150 patents for improvements in primary batteries have been applied for in Great Britain alone.

A question which presents itself in connection with the problem of economical lighting by primary batteries is this:—Is it not possible to effect economy in the lamps—to so improve the lamps that a given expenditure of energy on the part of the battery will develop more light in the lamps than is now obtained? Yes; it is possible. It would be troubling you too much to enter here into a lengthy account of the scientific principles which should guide the designer of the luminous conductors of incandescence lamps. It must suffice to say, that the ideally perfect conductor would assume a spherical form; its mass would be very small, and its surface also, and the material of which it was composed would possess the power, possessed unfortunately by no known substance, of enduring without change for an unlimited time the passage of a very powerful electric current. Of all substances hitherto used for incandescing conductors, carbon obtained by the intense heating of a pure hydro-carbon is the best. It will give a greater return in light for a given expenditure of energy, and will withstand the action of the current longer than any other substance. It becomes possible, therefore, by its aid to approach more nearly to the ideally perfect form of luminous conductor than we should otherwise be able to. If also we can so fashion the intimate structure of the carbon, that the particles already have that arrangement which they tend to assume under the action of the current, the type of perfection can be approached even more nearly. This has been done. In a patent obtained in November, 1882, by Messrs. Boulton and Soward, in conjunction with myself, a method was described by which luminous conductors can be obtained of pure deposited carbon formed under the influence of the electric current. By suitable means, these conductors can be obtained of any required degree of approximation to the theoretically perfect form. What thickness they will ultimately assume it is impossible yet to say. The shorter and finer they are made the greater is the economy, but the shorter is their life. The thickness at which the economy in action is just balanced by the increased cost of renewal of lamps is the practical working thickness, but this can only be determined by lengthy experiments, which are still in progress.

It may be noted in passing that high resistance luminous conductors—and they can be made without difficulty with a resistance of 1,000 ohms and upwards to the inch—have the great advantage that they work with a small current, although they necessarily require a somewhat high electromotive force. This enables the copper leads to be much thinner, and therefore less expensive, than in the case of a low resistance luminous conductor, worked by a large current, which is an important point worth bearing in mind.

Messrs. Woodhouse and Rawson have quite recently introduced a new lamp, which they call their "hair filament lamp." These lamps have an extremely thin, hair-like filament, whence their name. No particulars of the method of manufacturing these filaments have been published, but it appears that, like the filaments of my colleagues and myself, they are made of deposited carbon. The method of their preparation is carefully kept secret, doubtless for fear of piratical imitations, which although generally easily detected, are yet often hard to prove in a court of law. These filaments are stated to be very efficient. It is said that they will furnish a given amount of light with less then half the expenditure of energy necessary to furnish the same amount in an ordinary thick filament. This is doubtless true; the experiments of my colleagues and myself with our own filaments perfectly support this statement, and we have had the opportunity of experimenting with filaments of much greater length, and therefore light-giving power, than Messrs. Woodhouse and Rawson seem to have had, if a conclusion may be formed from the lamps before the public.

It is to be hoped that the many inventors of primary batteries who are doubtless present, will favour us with a fuller description of their inventions than the limits of this paper have permitted, and that an interesting and valuable discussion will ensue.

WILLIAM STURGEON.

Several readers have doubted the part played by William Sturgeon in the amalgamation of batteries, as mentioned in the notice of Mr. Sprague's book; others have wondered who Sturgeon was, and why he should be honoured at all. Last year the Philosophical Society of Manchester issued a work entitled "A Century of Science in Manchester," in celebration of the society's hundredth anniversary. This work was edited by the late R. Angus Smith, F.R.S., and Chapter XI. deals with Sturgeon and his claims. We reprint what is said of W. Sturgeon, leaving our readers to judge if he is not fully worthy of all the honour that can be given to a pioneer of science.

William Sturgeon, the electrician, as we may call him, or physicist, was born in Lancaster, and spent his time from 1838 to his death, December 8th, 1850, in close relations with the society, and it was here that he collected his works for publication. He was born in 1783, and as we learn from a graphic account by Dr. Joule, was reared under circumstances peculiarly suited to make a man rough, selfish, and unintellectual. To keep his father, a clever man but an idle shoemaker, poaching fish, and rearing game cocks when starving the family, was the painful work of the young Sturgeon, and to the very last he had a life of labour and poverty. The work he did was nevertheless surprising, and we give here a full list of his papers, although not done in any other case, because he was one of those men too neglected, both by the higher class of scientific men of the time and by the societies to which they belonged. It is sad to think that scientific men see no better than the public where real merit exists—surely this is nonsense, scientific men must see where science exists—well, let it be so then; they are not very well able to bring forward those who are neglected, or are they willing if able? It is to be feared that they are as other men, self being served first. It is true that at last he was seen by men of scientific eminence, and notably by our president, Mr. Binney, who, although not an electrician, was doing the work of others, and induced the Government to allow Mr. Sturgeon £50 per annum when he was old. Here also we have to make complaints. To him who hath shall be given. A sum so small would not have been offered to a man who had been fairly prosperous, but to a man who had suffered all his life this sum was to set a seal on his poverty and to continue his depression. But it is not intended to write his life. Dr. Leigh (now medical officer of health for Manchester) and Dr. Joule have written of him, and they knew him better than the writer of this did. It is enough, then, to add from their accounts the following, and first from John Leigh, F.R.C.S., &c., as it appeared in the *Manchester Examiner and Times*, December 14, 1850:—

"It was during his connection with the artillery that, as he once described to the writer of this brief notice, his attention was awakened, and his curiosity quickened, by the phenomena of a terrific thunderstorm. The whole phenomenon was a mystery to him, but he determined to become better acquainted with the wonderful agent that had so strongly excited his awe and admiration—a power that, in an instant, could rend rocks and rive trees, and yet whose visible existence was nowhere. The few books he was able to obtain afforded him little information, and even the perusal of those showed him that in education he was deficient in the elements essential to a physical investigator. With an energy and perseverance that characterised him through life, he resolved to overcome these difficulties; and he set about it in a manner that indicated the high order of his mind. He began at once the study of mathematics, of which he obtained an excellent knowledge. He then cultivated the Latin and Greek languages to a suffi-

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cient extent to enable him to understand the meaning and origin of scientific terms, and coin for himself such as he needed. French, German, and Italian he studied with much assiduity that he might read the researches of the great Continental philosophers. These languages, indeed, he read with considerable facility. Thus prepared, he entered on the study of natural philosophy, of which he obtained a sound knowledge; nevertheless, the phenomena of electricity and magnetism had ever the greatest charm for him. . . It is difficult to conceive a more unfavourable social position for the formation of a scientific character than that of a private soldier, the constant and wearying routine of duty, the want of privacy, the difficulty at the time of which we write of obtaining a fit supply of books, and the incessant temptations offered by companionship and a soldier's habits; and yet, surrounded by such difficulties, exposed to such temptations, and in such a position did Mr. Sturgeon master the numerous branches of knowledge, the possession of which gave to his researches and their exposition a clearness and precision that had scarcely ever been surpassed. Simple-minded and clear himself, imbued with an ardent love of truth, he had an utter abhorrence of scientific quackery, and never failed to express his contempt for those who substituted a pretended knowledge for its reality. He was exceedingly happy in devising experiments, and contriving the necessary apparatus—as may be seen by referring to Dr. Francis' 'Dictionary of Scientific Instruments'—and quick in perceiving the relations of the facts which he educed; and though it may be said that he never succeeded in the enunciation of a great law, yet no man has contributed to science a greater number of isolated discoveries of equal value and importance, or left behind him a greater number of instruments for others to work with. Some conception of his great labours and numerous contributions to science may be formed from the subjoined list of his papers:—

"1. 'An improved method of exhibiting M. Ampère's rotating electro-magnetic cylinders, by employing a horseshoe magnet instead of a bar magnet, as previously used.'—*Phil. Mag.*, September, 1823.

"2. 'On new electro-magnetic experiments.'—*Phil. Mag.*, February, 1824.

"3. 'Electro and thermo-magnetic experiments.'—*Phil. Mag.*, April, 1824.

"4. 'Description of a rotatory thermo-magnetic apparatus.' *Phil. Mag.*, April, 1824.

"5. 'On electro-magnetism.'—*Phil. Mag.*, October, 1824.

"6. 'On a new mode of showing the action which a magnet exercises on metallic discs, and on a novel phenomenon discovered thereby.'—*Edinburgh Phil. Jour.*, and *London Phil. Mag.*, August, 1825.

"7. 'Description of a complete set of improved electro-magnetic apparatus.'—*Trans. Soc. Arts* for 1825.

"8. 'On the ignition of gunpowder by the electric discharge, and on the transmission of electricity through water.'—*Phil. Mag.*, June, 1826.

"9. 'On the inflammation of gunpowder and other substances by electricity, with a proposal to employ the term momentum as expressive of a certain condition of the electric fluid.'

"10. 'Recent experimental researches in electro-magnetism and galvanism.'—Published by Mr. Sturgeon, in 1830.

"11. 'An account of an aurora borealis observed at Woolwich on the night of January 7, 1831.'—*Phil. Mag.*, 1831.

"12. 'On thermo-magnetism of homogeneous bodies.'—*Phil. Mag.* for July and August, 1831.

"13. 'On electro-magnets.'—*Phil. Mag.*, 1832.

"14. 'On the distribution and retention of magnetic-polarity in metallic bodies.'—*Phil. Mag.*, April and May, 1832.

"15. 'On the distribution of magnetic polarity in metallic bodies.'—*Phil. Mag.*, 1832.

"16. 'On the theory of magnetic electricity.'—*Phil. Mag.*, 1832, and *Annals of Electricity*, Vol. I.

"17. 'Description of an aurora borealis seen at Woolwich on the evening of December 22, 1834.'—*Phil. Mag.*, Jan., 1835.

"18. 'Description of a thunderstorm, as observed at Woolwich on June 14, 1834, with some observations on the cause of the deflection of the electric clouds by high lands, and an account of a peculiar phenomenon exhibited by means of a kite elevated during the storms.'—*Phil. Mag.*, December, 1834.

"19. 'Researches in electro-dynamics, experimental and theoretical.'—*Annals of Electricity, Magnetism, and Chemistry*, Vols. II. and V.

"20. 'On electro-pulsations and electro-momentum.'—*Phil. Mag.*, August, 1836. On October 1st, 1836, Mr. Sturgeon commenced a new scientific journal, called *The Annals of Electricity, Magnetism, and Chemistry*, and continued it, under his own superintendence, through ten octavo volumes.

"21. 'Description of an electro-magnetic engine for turning machinery.'—*Annals of Electricity*, &c., October, 1836.

"22. 'Description of two novel and brilliant electrical experiments, well calculated for the lecture table.'—*Annals of Electricity*, &c., January, 1837.

"23. 'An experimental investigation of the laws which govern the production of electric shocks, and other phenomena by a single pair of metals.'—*Annals of Electricity*, Vol. I.

"24. 'Application of the theory of magnetic electricity, and of the laws of electro-magnetism, to the explication of phenomena.'—*Annals of Electricity*, Vol. I.

"25. 'An inquiry into the attributes of the galvanometer, and how far its indications may be depended upon in electro-dynamic researches.'—*Annals of Electricity*, Oct., 1836.

"26. 'An experimental investigation of the influence of electric currents on soft iron as regards the thickness of the metal requisite to a full display of magnetic action, and how far these pieces of iron are available for practical purposes.'—*Annals of Electricity*, Oct. 1837.

"27. 'Experimental and theoretical researches in electricity.' Read before the London Electrical Society, Dec. 5, 1837.

"28. 'An investigation of the causes of the fracture of glass during an electric discharge, and on the mode of protecting it.' Read before the London Electrical Society, January 6, 1838.—*Annals of Electricity*, Vol. II.

"29. 'Researches in electro-dynamics, experimental and theoretical.'—*Annals of Electricity*, Vol. II.

"30. 'Experimental and theoretical researches in electricity.' Read before the London Electrical Society.

"31. 'Description of three different instruments for opening and shutting the battery circuit of an electro-magnetic coil machine.'—*Annals of Electricity*, Vol. III.

"32. 'Description of an aurora borealis which appeared in London on the evening of September 29, 1838.'—*Annals of Electricity*, Vol. III.

"33. 'Experimental and theoretical researches in electricity and magnetism.' Read before the London Electrical Society, December 4, 1838.

"34. 'Experimental and theoretical researches in electricity and magnetism.'—*Annals of Electricity*, Vol. IV.

"35. 'On the use of voltaic electricity in electro-gilding and silvering.'—*Annals of Electricity*, Vol. IV.

"36. 'Description of an aurora borealis observed in London.'—*Annals of Electricity*, Vol. IV.

"37. 'Description of an original cast-iron voltaic battery, and an account of some of its performances.'—*Annals of Electricity*, Vol. V.

"38. 'Experimental and theoretical researches in electricity and magnetism.'—*Annals of Electricity*, Vol. V.

"39. 'Results of galvanic experiments made on Clapham Common in autumn of 1838.'—*Annals of Electricity*, Vol. V.

"40. 'Experimental and theoretical researches in electricity and magnetism, &c.'—*Annals of Electricity*, Vol. VI.

"41. 'Examination and report of the effects of lightning on St. Michael's Church, Liverpool.'—*Annals of Electricity*, Vol. VII.

"42. 'Experimental and theoretical researches in electricity magnetism, &c.'—*Annals of Electricity*, Vol. VIII.

"43. 'Description of an aurora borealis seen at Manchester, on Wednesday, April 5, 1843.'—*Annals of Electricity*, Vol. X.

"44. 'On some peculiarities in the magnetism of ferruginous bodies.'—*Manchester Memoirs* for 1845.

"45. 'On a peculiar source of deterioration of the powers

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of magnetic bars.'—Read before the Royal Society, May, 1845.

"46. 'On the electro-culture of farm crops.'—*Transactions* of the Highland Agricultural Society.

"47. 'An experimental investigation of the magnetic characters of simple bodies, metals, metallic alloys, and metallic salts.'—*Memoirs* of Manchester Literary and Philosophical Society, 1846.

"48. 'Three accounts of the aurora borealis, and on the formation of clouds as observed in the locality of Kirkby Lonsdale.'—*Memoirs* of Manchester Literary and Philosophical Society, Vol. VIII.

"49. 'On lightning and lightning conductors.'—March 21, 1848.

"50. 'On the peculiarities of the thunderstorm which occurred in this neighbourhood on July 18th last.'—Posthumous paper, date uncertain; Manchester Literary and Philosophical Society, read March 4, 1856.

"Mr. Sturgeon has also published two elementary treatises, one on electricity, the other on galvanism, besides some smaller works, the last of which was entitled 'Practical Instructions for the Protection of Persons and Property from the Effects of Lightning.'

"For a set of improved electro-magnetic apparatus, Mr. Sturgeon received in 1825 the large silver medal of the Society of Arts, together with thirty guineas.

"The following statement of some of his most important discoveries in a letter from the pen of the most distinguished physicist now left to us in Manchester is an admirable testimony to his great scientific merits, and cannot be read without interest:

"'My dear Sir: I have sifted Mr. Sturgeon's claims to the utmost. I have examined all the periodicals likely to throw light upon the history of electro-magnetism, and find that Mr. Sturgeon is, without doubt, the originator of the electro-magnet, as well as the author of the improved electro-magnetic machine. The electro-magnet described by Mr. Sturgeon in the *Transactions* of the Society of Arts for 1825 is the first piece of apparatus to which the name could with propriety be applied. Arago and Ampère and Davy had already, it is true, magnetised steel needles by passing currents of electricity along spirals surrounding them, but it does not appear that they observed the phenomena with iron needles, nor that they had any knowledge of the suddenness with which the polarity of soft wrought iron might be reversed by a change in the direction of the current. It appears, therefore, quite clear that to Mr. Sturgeon belongs the merit of producing the first electro-magnet constructed of soft iron, as well as that of ascertaining its peculiar and most remarkable properties. *Hence it was that M. Jacobi, of St. Petersburg, claimed for Mr. Sturgeon, in conjunction with Proessor Œrsted, the discovery of the electro-magnetic engine.* Mr. Sturgeon's claims with regard to the magneto-electrical machine appear to me to be equally well established. He was the first who devised and executed an apparatus for throwing the opposing currents into one direction, thus accomplishing for this machine exactly what Watt accomplished for the steam engine. Beside this, he is beyond dispute the author of the systems of solid brass discs and insulators going by the name of 'commutator' on the Continent and 'unitress' in America, an apparatus now universally employed in every magneto-electrical machine. Mr. Sturgeon was without doubt the constructor of the first rotary electro-magnetic engine.

"'The use of amalgamated zinc plates in the voltaic battery was originated by Mr. Sturgeon. It is an improvement of such value that it has been universally adopted ever since, although all other arrangements of equal date have been superseded.

"'Mr. Sturgeon's discoveries in the thermo-electricity and magnetism of homogeneous bodies are very important, and have placed his name higher than that of any other philosopher who, after Seebeck, has cultivated thermo-electricity.

"'The above is only a very imperfect abstract of a small part of Mr. Sturgeon's discoveries and improvements in magnetism, electricity, and the kindred sciences. Though not himself the author of extensive generalisations, he has been signally useful in preparing the way for them, and in carrying them out practically; and I know not of one individual who, under equal or even less disadvantages, has contributed so eminently to the advancement of these highly interesting and useful sciences.—(Signed) James P. Joule.'

"Soon after he left the army, Mr. Sturgeon was appointed Professor of Natural Philosophy in the Military Academy at Addiscombe, where he continued to lecture until he came down to Manchester to superintend the Victoria Gallery of Practical Science. The pressure of the times very soon necessitated the discontinuance of this institution, and Mr. Sturgeon was then unhappily deprived of any means of existence but the very precarious one arising from occasional courses of lectures. After struggling with difficulties which would have weighed many men down, he was at length, by the intercession of his friends, placed by Lord John Russell on the civil list for a pension of £50 per annum, but which he has lived a very short time only to enjoy, having but received one year and one quarter's allowance. Some time ago he resolved on collecting his numerous papers together and publishing them in one handsome quarto volume, which has been a short time before the public, and as a specimen of provincial topography has seldom been equalled.

"After tracing his career and contemplating the many valuable discoveries he gave to his country, it is painful to think that his last years were embittered by privations and pecuniary anxieties that must have preyed upon his mind and destroyed his comforts, and that at last he has left a wife and her daughter totally unprovided for.

"There is little inducement held out in this country to the cultivation of science, whilst the scientific men of other countries are ennobled, honoured, and placed in comparative affluence, as witness Professor Œrsted, a labourer in the same field with poor Sturgeon. Here they are neglected, unrewarded, and left to pine in poverty and want. The world uses their discoveries, heedless that the head that gave them moulders in the grave, the victim of its own mighty efforts, and of their ingratitude.

"In the *Athenæum* of November 23, 1850, is the following paragraph:—'At Copenhagen, Dr. Œrsted, the well-known discoverer of electro-magnetism, has been celebrating the fiftieth anniversary of his appointment at the Royal University of that city. We English are not accustomed to have our literary men spoilt as they spoil them in Denmark and some other civilised countries. All ranks contended to do the philosopher honour on this occasion. The King sent him the Grand Cross of the Order of Dannebrog. The university sent new insignia of his doctor's degree, including a gold ring, whereon a cameo bears the head of Minerva; and the citizens presented him with a beautiful villa, situated at Fredericksburg, in the outskirts of Copenhagen. King and people agree in a strange estimate of the value and status of the scientific man, according to our insular notions. We do not see how they could have improved on this sort of testimonial if he had gained a battle. Dr. Œrsted is upwards of eighty years of age.'"

Dr. Joule has viewed the matter from another point. His account of Sturgeon's discovery is of importance, establishing the scientific position of the too much forgotten discoverer.

After describing Mr. Sturgeon's improvements on the voltaic revolving machine, the result of discoveries by Œrsted, Faraday, Ampère, and Barlow, Dr. Joule says (*see* "On the Life and Writings of the late Mr. William Sturgeon," by Dr. James Prescott Joule, F.R.S., &c., *Mem. of the Lit. and Phil. Soc.*, Vol. XIV., 2nd Series, p. 59):—

"In 1824 Mr. Sturgeon began to give the fruits of his investigations to the public in the leading scientific periodical of the day. In that year no fewer than four papers of great merit appeared from his pen on the subjects of 'Electro and thermo-electricity' in the pages of the London *Phil. Mag.*

"In 1825 he published in the *Transactions* of the Society of Arts 'the description of a complete set of novel electro-magnetic apparatus.' The great merit of this apparatus consisted in the improved adaptation of the magnets, batteries, &c., to one another, by means of which Mr. Sturgeon was enabled to

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perform, with a voltaic battery of the size of a pint pot, experiments which had previously required the use of a cumbrous and costly battery. The Society of Arts testified their sense of the importance of this contribution by awarding to its author their large silver medal, with a purse of thirty guineas.

"About this time Mr. Sturgeon made his great discovery of the *soft iron electro-magnet*, and having observed the high degree of polarity acquired by a straight bar of iron on making a current of electricity to circulate around it, as well as the suddenness with which the direction of polarity could be reversed by changing the direction of the current, he proceeded to construct electro-magnets on the same principle, but bent into the form of a horseshoe, so that the poles, by being brought near one another, could concentrate their action on any given object. This *soft iron electro-magnet has entered into the structure of every form of electric telegraph.*

"Passing over several highly valuable communications to the *Philosophical Magazine*, which, even at this day, would amply repay a careful study, we find him in 1830 publishing a pamphlet, entitled 'Experimental Researches in Electro-Magnetism, Galvanism, &c.,' comprising an extensive series of original experiments. In this work Mr. Sturgeon first pointed out the superior effects to be derived from the use of amalgamated plates of rolled zinc in the voltaic battery instead of the unprepared cast zinc then in general use. He prepared his plates by dipping them first into a dilute solution of acid to cleanse their surfaces, and afterwards plunging them into mercury. He showed that plates prepared in this way do not effervesce in dilute sulphuric acid, as the unprepared plates do, and in consequence require to be much less frequently renewed than the latter, whilst, at the same time, the electric current produced is much more intense and constant. It is a remarkable fact that no further improvement has been effected in the preparation of the positive plates of the galvanic apparatus, and that Mr. Sturgeon's amalgamated zinc plates are at the present day employed in every form of improved battery, whether patented or not.

"In our chronological arrangement of Mr. Sturgeon's discoveries we may next note a highly valuable paper on the Thermo-Magnetism of Homogeneous Bodies, a work the merit of which can only be duly appreciated by those who are acquainted with the extreme minuteness of the currents of which it was the object to discover the existence and direction. By a happy combination of industry and sagacity our author succeeded in proving that electric currents can be developed in any individual mass of pure metal by a mere disturbance of temperature at some particular point, and that the direction of those currents is determined by the position of the point of greatest heat and the crystalline structure of the metal, a fact of the highest importance, and which, along with others developed by him about the same time, paved the way to Dr. Faraday's celebrated discovery of magnetic electricity.

"In 1836 Mr. Sturgeon communicated a paper to the Royal Society, which contains a description of a perfectly original magnetic electrical machine,* in which a most ingenious contrivance was adopted for uniting the reciprocating electric currents developed, so as to give them one uniform direction. By this contrivance Mr. Sturgeon succeeded in producing all the effects due to ordinary voltaic currents, by means of the action of magnets on rotating coils of wire. In the same year the great industry of Mr. Sturgeon was rewarded by two other important inventions. The first of these was that of the electro-magnetic coil machine, an instrument devised for the purpose of giving a succession of electric shocks in medical treatment, and which has been generally preferred by medical men to all others intended for similar purposes. The other was an electro-magnetic engine for giving motion to machinery.

"In 1838 Mr. Sturgeon noticed a highly interesting electric calorific phenomenon, produced by a powerful battery of one hundred and sixty pairs, provided by Mr. Gassiot and Mr. Mason. On breaking the battery circuit it was observed that the disruptive discharge of electricity made the positive wire red hot, while the negative remained comparatively cool. Mr. Sturgeon applied this fact to elucidate some important points in the theory of heat.

"About this time also Mr. Sturgeon prepared a paper for the British Association for the Advancement of Science on the very important subject of *Marine Lightning Conductors*. His researches on the subject enabled him to point out the danger likely to arise from the conductors then proposed for use in the Royal Navy by Sir W. Snow Harris, by which the lightning was sought to be conveyed through the body of the ship. He propounded at the same time a new system whereby this danger might be obviated.

"In 1843, Mr. Sturgeon published a memoir in the *Transactions* of the Literary and Philosophical Society of this town, 'On the Direct Action of Caloric on Magnetic Poles, and the Displacement of Magnetic Action in Soft Iron by the Influence of Heat.' The latter part of these researches develop some curious facts respecting the total absence of magnetic action in soft iron when made red hot, and point out by what means a bar may be converted into several magnets at one and the same time.

"We notice another memoir of even greater importance in the *Proceedings* of the same body for 1846, entitled, 'An Experimental Investigation of the Magnetic Characters of Simple Metals, Metallic Alloys, and Salts.' The very extraordinary fact arrived at by this research was that *several metallic alloys become endued with magnetic properties, although the constituents separately show no such action; and that iron and nickel, two metals which, whilst pure, are susceptible of the highest magnetic powers, become almost totally inert to magnetic action when combined with some other metals.*

"The subject of atmospheric electricity was one to which Mr. Sturgeon devoted a great deal of attention from the commencement of his scientific career to within a short period of his decease. Not satisfied with the ordinary apparatus in use at the electrical observatories, he elevated exploring kites into the atmosphere, and in all seasons and weathers, and even in some instances at considerable risk to his life, did he pursue this important branch of meteorology. The result of more than *five hundred* kite observations established the important fact that the atmosphere is in serene weather uniformly positive with regard to the earth, and that the higher we ascend the more positive does it become; so that if the strata in which the kites are immersed are at altitudes corresponding to the series 1, 2, 3, 4, 5, their relative states of positive electricity would be conveniently represented by those numbers.

"Besides the above and a multitude of other researches which we have not room to notice, but which in a complete biography it would be impossible to pass in silence, Mr. Sturgeon was an ardent admirer and diligent observer of those grand and magnificent instances of the Creator's power which are exhibited alike in the lightning flash and the silent corruscations of the aurora borealis. Most graphic and highly interesting accounts of these natural phenomena appear interspersed among his more elaborate papers.

"The magnitude of Mr. Sturgeon's scientific labours would naturally lead one to imagine that his whole life was given up to original investigation. On the contrary a large portion of his time was occupied in communicating his stores of knowledge to others. For several years he filled with great credit to himself the chair of Experimental Philosophy in the Hon. East India Company's Military Seminary, Addiscombe. In 1838 he accepted the office of Superintendent of the Royal Victoria Gallery of Practical Science in this town, and subsequently to the failure of that institution, through the pressure of the times, he made strenuous though unfortunately unsuccessful efforts to establish another institution of a kindred character. As a lecturer he was distinguished by the happy facility with which he conveyed the truths of science to his hearers, and the uniform success of his experimental illustrations. Nor did he confine his efforts to mere oral enunciation. The numerous elementary treatises which he published on electricity, magnetism, and chemistry, show the desire he had to extend sound knowledge as widely as possible. At the same time he performed a real service to the cultivators of science by establishing

* This instrument is the precursor of the variety of modern dynamo-electric machines employed for the electric light, electro-plating, telegraphing, &c.

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a new scientific journal, entitled *The Annals of Electricity, Magnetism and Chemistry, and Guardian of Experimental Science*, which he continued with unexampled industry and perseverance through ten octavo volumes. This work became a medium of much valuable information; and its success gave rise to a similar publication on the Continent, under the editorship of Professor de la Rive. Mr. Sturgeon's last work, which he completed only a few weeks before his death, was to collect into one large quarto volume the whole of his published papers. This work, which is got up in a first-rate style, and is illustrated by eighteen beautifully engraved plates, should be studied by all who wish to obtain a thorough knowledge of electrical science.

"In stature Mr. Sturgeon was above the average height, and his open brow and upright carriage conveyed the impression of integrity of character, an impresson which was sure to be deepened by a personal acquaintance. As a friend he was warm-hearted and generous, and always prompt in acknowledging the merit of others where merit was really due. To the widow and adopted daughter left is best known his sterling worth in the domestic circle. In politics he was a Conservative, though it will be readily believed he had no time to enter the arena of party strife. Conscientiously attached to the Church of England, he enjoyed the friendship of many of its distinguished ornaments.

"In Mr. Sturgeon we have lost a man of high moral worth and European reputation, and it may be doubted whether, with the single exception of Dalton, the Scientific Society of Manchester has ever experienced a severer calamity than by his death."

In a somewhat fuller account of Sturgeon, written by Dr. Joule, and published in the Society's *Memoirs*, Vol. XIV., 2nd Series, 1856-7, p. 78, the following specimen of his writing is given :—

"The electric fluid is so universally diffused throughout every part of nature's productions, that every particle of created matter, both animate and inanimate, which has hitherto been contemplated by the philosophers, is full of this surprising animated elemental fire.

"In regions far above the surface of the earth, where the air is much attenuated and so far thinned, near to the utmost verge of the atmosphere, as to become a conducting medium, the electric element plays its quivering streamers and sparkling corruscations in the beautiful aurora of the north. Sometimes this rare—this fascinating phenomenon—is exhibited in a steady glowing arch of light, whilst at others it expands its dancing network in transient display over the whole concave of the visible heavens.

"At altitudes less elevated than those which form the grand theatre for the display of the aurora borealis the electric discharges become more compact, and shoot slanting downwards on bright serene evenings these beautiful gleaming orbs of meteoric light which from ancient custom are still called falling stars.

"Still less elevated in the atmosphere the long black clouds swell with the electrical element in all those grand magnificent and splendid forms of lightning, with their tremendous peals of thunder, so frequently displayed in most countries during the transient rage of a majestic summer's storm.

"Descending to the earth we trace its circumfluent streams polarising this vast ball of matter, on which we are destined to live and perform all our actions, and insinuating its resistless influence in all the silent mysterious attractions of the magnet. Trace it to the laboratory of the chemist, and we find it the most active and vigorous agent in accomplishing all those astonishing changes which give new forms and new qualities to passive obedient matter.

"Besides all these important operations of nature, accomplished by the agency of electricity, it is capable of restoring the dormant muscular and nervous powers of man which have been prostrate by accident or disease, and of giving new life and new vigour to every other mode of medical treatment.

"In plants, also, as well as in animals, it is said to facilitate growth, and to give health, vigour, and heart to their general appearance.

"Indeed, so *universally* does the electric fluid appear to be employed in *most*, if not *all*, the grand processes of nature, and there is not, perhaps, a plant that grows or a limb that moves but is in some measure influenced by its powers.

"Nay, it is perhaps this astonishing, this most gigantic of physical agents, which is employed by the Great Creator to spin the earth and planets on their axes, to sweep them through the heavens in their regular periods of revolutions, and to keep in uniform motion all those massy orbs of matter which compose the countless systems of the universe.

"Brief and imperfect as is the outline which I have thus portrayed of the individual branch of science, perhaps we may venture to ask who is there, then, who knows the advantages, beauties—nay, the pleasures of scientific knowledge—who would think his time misspent, or his labours useless, in the accomplishment of so noble an acquisition?"

Dr. Joule says:—"Mr. Sturgeon was of a tall and well-built frame of body, his forehead was high, and his features were strongly marked. His address was animated, and his conversation, as it generally is when the mind is stored with knowledge, pleasing and instructive. His style of writing was at once vigorous, lucid, and graceful. In friendship he was warm and steady, in domestic life affectionate and exemplary. He had a noble mind and a generous heart. He was a close and sagacious reasoner, and an unsparing exposer of error. He detected quackery and false pretension, sought diligently for truth, and loved it for its own sake. A diligent accumulator and observer of facts, eager in the pursuit of information of whatever kind, and in communicating his stores to others, under more fortunate circumstances he would probably have left a name unsurpassed in the scientific history of his time; as it is, he will always be remembered as a distinguished cultivator of natural knowledge."

To all this we agree heartily, and feel at the same time the extreme difficulty there is in this and perhaps in any country in Europe in any man obtaining a good position in any scientific establishment unless he enters in by the colleges or universities, or has made early friendships of those who have. By their means he is put on the track of promotion, and otherwise he is often an outcast. We must feel how remarkable the influence of Sturgeon has been in developing the electrical apparatus of the present day. The results which are exciting the world are obtained by inventions begun by him, and he probably foresaw much of their value to the world.

LEGAL.

Muir and Co. v. the Anglo-American Brush Electric Light Company.

This case came before Mr. Justice Field, Mr. Justice Manisty, and Mr. Justice Lopes, in the Queen's Bench Division of the High Court of Justice, on the 26th June. We take the following report from *The Times*:—This was a very remarkable case in its history, and it also raised a curious and interesting question, which has for two years perplexed the Courts. It was remarkable, for it was an application for a fourth trial in a case which had already been three times tried, and had been repeatedly before the Divisional Courts, and once or twice in the Court of Appeal, and it raised, moreover, a very interesting question. It was an action upon a contract entered into by letters in 1882, under which the company were to take a new and peculiar machine for boring "electric generators," which would weigh about 15 tons, and of which the price was to be £736, but which the company had declined to receive, upon the ground that it was delivered too late, not having been completed until after a lapse of nine months. The dispute had been as to the time within which the machine was to be completed, the company wishing to have it in a certain time, and as the plaintiffs, the makers, had agreed to "do their best to complete it as nearly as they could" within that time, the question which had arisen, and which had sorely perplexed both judges and juries, was what those terms really meant, and within what time the machine was to be completed. The company had desired it to be delivered in eight or nine weeks. The plaintiffs replied that it was quite impossible to do it in less than 13 or 14 weeks. Afterwards the plaintiffs wrote that they would do their best to deliver the machine as nearly as possible "in eight or nine weeks," and the great question in the case which had puzzled the Courts and perplexed the Court of Appeal was what those words meant. In point of fact the machine was not completed until eight or nine months afterwards, during which period, however, until just at the end of it, the company never applied for it, and the plaintiffs, finding it not pressed for, did not use extra endeavours to complete it, and the

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machine being very large and complicated, it took a great deal of care and labour to finish it, and the plaintiffs gave much evidence as to this—that the machine comprised 1,840 distinct parts, that as many men as could be were employed upon it, and there was no unavoidable delay about it Moreover, it cost £150 more in making than had been estimated; that they had "done their best" to finish it as soon as possible, and that nine months was a reasonable time for making it, though they admitted that if the contract had been to finish it in a specified time they would have put extra men upon it, and kept them at work extra hours. On the other side, there was evidence that the machine could have been finished in three months. On the whole of the evidence the jury at the first trial before Mr. Justice Pearson at Manchester found in favour of the plaintiffs. That verdict, however, was set aside on the ground that the judge had not adequately directed the attention of the jury to all the letters which had passed between the parties. Then there was a second trial before Mr. Justice Butt and a special jury at Manchester, when the jury could not agree, and the learned judge then took the matter into his own hands and directed a verdict for the company. This, however, a Divisional Court had thought was wrong, the question being for the jury, and on an appeal the Court of Appeal took the same view, and directed the case to be tried a third time. It had accordingly been tried a third time before Mr. Justice Day and a special jury at Manchester, and, after full evidence—some of it skilled and scientific—on both sides, the learned Judge left the question to the jury, with a summing up rather in favour of the company, but the jury found for the plaintiffs for £750. This was an application on the part of the company—the defendants—for a new trial on the ground that the verdict was against the evidence.

Mr. Henn Collins, Q.C. (with Mr. Gully, Q.C.), appeared for the defendants; Mr. Ambrose, Q.C., and Mr. Bigham, Q.C., were for the plaintiffs in support of the verdict in their favour.

As soon as the case was opened,

The COURT asked what the words in the contract as to time were to be taken to mean. Counsel answered that this was the question which had puzzled the Courts and even perplexed the Court of Appeal, which had tried to settle it, but had not, perhaps, succeeded in so doing. In effect the Court had held that it meant this—that the plaintiffs were bound to do their best to deliver the machine within the period fixed, which they said meant more than to do it in a reasonable time, regar l being had to the nature of the machine and the time required to construct it. [Mr. Justice FIELD said the case had been tried three times, and twice with a verdict for the plaintiffs, and now the defendants desired it to be sent to a fourth trial.] After a certain number of trials the Court can enter the verdict as they think fit. [Mr. Justice LOPES: That would be contrary to the decision of the Court of Appeal in this very case—that it is a question for the jury.] [Mr. Justice FIELD said there were cases in which verdicts of juries had been set aside again and again when wrong.]

The learned Judges here conferred together, and

Mr. Justice FIELD said would it not be better that, to avoid a fourth trial of the case, the parties should try to settle it? The machine was made, and must be worth something.

Counsel answered that the machine was now obsolete, having been superseded by others, and it was now only worth the price of waste iron. Besides, the costs were now so serious that they were larger than the price of the machine. The parties had tried again and again to settle it and had failed.

Mr. Justice FIELD said it was sad to think of a case already tried three times being tried again.

Counsel said they feared it could not be settled, and so the case proceeded. The counsel for the company offered an affidavit that two of the jury had stated that they had given their verdict on a certain ground, but the Court refused to receive it, and the case was argued on the evidence, on which the counsel for the company contended that the plaintiffs had "not done their best" to finish the machine within the eight or nine weeks.

Mr. Justice FIELD, however, asked what "doing their best" meant? Did it mean putting 500 or 5,000 men on the work, if necessary, to finish it in the time mentioned? Surely it could not mean that—to which the counsel for the company assented; but said it was for the jury.

Mr. Justice FIELD observed, upon this, that the jury had found in favour of the plaintiffs, and how was the Court to determine the question?

After hearing counsel on both sides at considerable length, and fully considering the case,

The COURT came to the conclusion that they ought not to set aside this verdict. The Courts, they said, were bound to pay due respect to the verdicts of juries, and it was for the party who desired to set aside a verdict as against evidence to make it out very clearly that it was against the evidence. This was peculiarly so in a case such as the present, which turned on matters of business, and the question was peculiarly for a jury. The machine to be made was of a very difficult and peculiar character, and engineers of the highest reputation had given it as their opinion that the time taken in making it was, under all the circumstances, very reasonable. No doubt the time of completing it was material on both sides, and considering the difficulty of making it, which the plaintiffs had pointed out, they at first said they could not undertake to make it in less than thirteen or fourteen weeks. That, however, was not accepted, and ultimately it was agreed that the plaintiffs should "do their best" to finish it as nearly as possible in eight or nine weeks, and that raised a question for the jury which had already been three times tried, twice in favour of the plaintiff, and now the Court was asked to set that verdict aside and send the case to a fourth trial. That was extremely undesirable if it could be avoided, though they should not shrink from doing it if it were really necessary to justice. But this rendered it necessary to look closely into the grounds on which the verdict was complained of. Certainly some of these grounds were not devoid of strength, and the Court were not sure they would have found the same verdict. On *primâ facie* evidence it did seem strange that a manufacturer who had only asked three months to make the machine had taken nine months to make it. It certainly had been urged that the company for nine months had not asked for it, and that, therefore, the plaintiffs had supposed they were in no great hurry for it. That ground, however, for delay had not been made out, but on the whole evidence, and especially the delay on the part of the company, the case had been properly left to the jury, and there were no sufficient grounds for disturbing the verdict. The case now, at all events, had been fully tried by the jury on a proper direction, and as the question was for them the time had now come to put a stop to this sad litigation, and therefore the verdict must stand and this application for a new trial be dismissed with costs.

Clark v. Bennett.

In the High Court of Justice, Queen's Bench Division, on Monday last, before Mr. Justice Hawkins and a special jury, an action was brought by Captain Arthur Hamilton Clark against Mr. James Gordon Bennett, proprietor of the *New York Herald*, in which the plaintiff sought to recover £5,000 as remuneration for services alleged to have been rendered the defendant at his request. The defendant paid £859 into court as sufficient to meet all claims which the plaintiff might have against him.

The Attorney-General, Mr. E. Clarke, Q.C., and Mr. C. H. Anderson appeared for the plaintiff; and Mr. R. Webster, Q.C., and Mr. Jeune were counsel for the defendant.

The ATTORNEY-GENERAL, in opening the plaintiff's case, stated that the plaintiff was an underwriter, who at the time he was retained to carry out the work for which he now sought payment was earning about £2,000 a year. The defendant was Mr. James Gordon Bennett, a well-known American, of journalistic repute, and owner of the *New York Herald*. It appeared that about the year 1882 Mr. Bennett had reason to fear the rivalry of Mr. Jay Gould's system of telegraphic news agency, and was desirous of establishing a new cable between America and Europe over which he should have absolute command. It was with the object of promoting and carrying out this scheme that he had engaged the services of Captain Clark, the plaintiff, and it was for such services that that gentleman now sought payment. The plaintiff worked most assiduously at getting up the proposed company, the Articles of Association of which made provision that he should be paid a yearly salary of £3,000. Eventually—for what reason he did not know—Mr. Bennett had thought proper to throw over the first scheme for establishing the new cable, and had entered into fresh plans, with a similar object, with the great American capitalist, Mr. Mackay; but that was no reason why Captain Clark, the plaintiff, should not be adequately paid for all his trouble with the original scheme, and compensated for any damage which his business might have suffered by reason of his not having been able to devote all his time to it, as he would otherwise have done.

Captain Arthur Hamilton Clark, called, said that previously to August, 1882, he had known Mr. James Gordon Bennett for some years. He had carried on a business in this country as the agent to American underwriters. In August, 1882, he received a telegram containing a message from Mr. Bennett, who is the proprietor of the *New York Herald*. The telegram was put in, and was dated the 22nd of August, 1882; it was from a Mr. Longfellow, and contained a request from Mr. Bennett asking the plaintiff to go over and meet him on his yacht, the "Namouna," at Cowes. He went, and Mr. Bennett stated that, as Mr. Gould controlled the lines of the Western Union Telegraph Company, he would be compelled to form a new line; Mr. Pender and Mr. Gould, in conjunction, also controlled the Atlantic lines. Further, Mr. Bennett said that Mr. Jay Gould was buying up two or three of the principal newspapers in New York, and that he would soon be in a position to crush him (Mr. Bennett). For these reasons he proposed to lay a new cable, and he thought, perhaps, Mr. Garrett, the president of the Iowa Railway Company and a large telegraphic line proprietor, might join him. But however this might be, he wished him (the plaintiff) to act for him (the defendant) in the matter. Witness continued: Mr. Bennett then asked me what I was making in my business, and what would make it worth while my accepting his offer. I replied that I was making £2,000 a year. Mr. Bennett replied, "Oh, I would pay you £3,000 a year." He asked whether I would like to put any money into the concern. I answered that I should, but not being a capitalist it would not be much—about £3,000. He then said, "I would give you 10,000dols."—*i.e.*, about £2,000 worth of shares, to make it £5,000 in all. I remained some days on the yacht, and returned to London on the 1st September, with the object of at once setting to work to gather all the necessary information requisite to the immediate promotion of the proposed company. The witness here detailed the various scientific persons with whom he consulted, and the various particulars of his services upon which he relied to substantiate his claim, and added—On the 30th of September, 1882, I wrote a letter to Mr. Bennett relative to the matters in hand, and asked to have my real position determined. Shortly after this I had gone to Paris to see Mr. Bennett early in October. Mr. Bennett referred to my letter, and asked me if £3,000 a year salary would satisfy me. I replied that it would. He further said that he was going to give me the 10,000dols. interest in the company besides. This was his own private matter, but Mr. Garrett agreed to the salary. We also discussed cable matters, and it was arranged that I should continue my preliminary efforts in furtherance of Mr. Bennett's views, and promoting his new cable. I returned to London and worked on, and when Mr. Bennett returned from America, on the 17th of November, I met him at Queenstown, and detailed to him all I had done, and laid before him the correspondence, expert reports, and other documents

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relative to the scheme. Mr. Bennett told me that he had seen Mr. Garrett in New York, and had arranged everything with him, and wished to form a company as soon as possible. Subsequently to this Articles of Association were drawn up. These contained a provision appointing me as managing director in the proposed company, at a yearly salary of £3,000. I took these over to Paris to show Mr. Bennett at his request. Mr. Bennett made no objection to that provision. These were signed in London by Mr. Bennett on the 30th of November, 1882.

Mr. Justice HAWKINS said that it appeared to him to be a case that must ultimately resolve itself into questions of detail which could much better be dealt with elsewhere.

At the suggestion of the learned Judge a consultation ensued, the result of which was that the case was referred to a gentlaman—to be named by the counsel for the plaintiff—to settle all matters,

Mr. WEBSTER, Q.C., stating that, on behalf of Mr. Bennett, he was prepared to have the question determined, not upon legal grounds, but as between gentleman and gentleman, whether the plaintiff was entitled to any advance on the sum paid into court or not.

The Corporation of Bristol v. the United Telephone Company.

On Tuesday this case came before Mr. Justice Cave in the High Court of Justice. The plaintiffs claimed the right to have some kind of control over the erection of telegraph wires within their city; and they claimed this first in the case where wires were carried over lands which were vested in them in fee; and, secondly, where wires, being carried over streets, might be a source of danger to the public. It was said that these last-named wires might come down in a high wind, a snowstorm, or in the case of a house being on fire.

The Solicitor-General, Mr. Philbrick, Q.C., and Mr. Casserley were for the plaintiffs; and Mr. Webster, Q.C., and Mr. Moulton for the defendants.

After some discussion it was admitted that the plaintiffs had absolute right of control where wires passed over their freehold land; and it was agreed that as to any other wire which was supposed to be a source of danger, that question should be decided out of court. In the end the case was adjourned *sine die* to allow time for this arrangement to be carried out.

THE INVENTORS' INSTITUTE.

On Wednesday last the members of this institute held what might be termed a field day at the Health Exhibition. The meeting was announced for two o'clock, and the members and guests then started from the jury room under the guidance of Mr. S. J. Mackie, C.E., to inspect various exhibits. Amongst other things attention was directed to the model dairies, and general satisfaction was expressed with the arrangements therein. The street of "Old London" was visited, and the various works carried on in the shops. This production, from the designs of Mr. Birch, is really one of the wonders of 1884, and attracts as much attention as any part of the exhibition. The engines of Messrs. Davey, Paxman, and Co., in the electric light department, were seen, and then the members proceeded to the New Technical Institute, where they had explained to them the experiments being carried out to study the propagation of various forms of bacteria. Then other exhibits were visited till seven o'clock, when dinner was served in the jury room. The wine at dinner was provided by the liberality of Mr. Prinie, the representative of Italy at the exhibition, and was accorded the highest praise. Vice-Admiral J. Selwyn presided. After the usual loyal toasts "The Services" was proposed, Colonel Hope, V.C., responding for the army, and Captain Fairholme, R.N., for the navy. Mr. Gooch proposed "The Inventors' Institute," briefly referring to the value conferred upon humanity by inventors, pointing out that the institute should take a very high position and be well supported in its endeavours to put inventors and inventions upon a proper footing with the world at large. Mr. Stanfield responded, and spoke with great enthusiasm of the labours of Trevethick, of Wedgewood, and other pioneers in the industrial inventions of England. He maintained that we were not only a nation of improvers, but a nation of inventors, pointing his moral from the works of the men he named. Other toasts were drunk, one of which was the health of Mr. Mackie, the guide of the day. A pleasant evening concluded with the health of the chairman.

Before concluding this cursory notice of the proceedings, we may be allowed to make known the work and objects of the institute, which are thus stated:—

The objects of this institution are to afford opportunities to inventors of reading papers or exhibiting their inventions at its evening meetings; to facilitate the diffusion of information with regard to inventions generally; and to furnish a rendezvous for the interchange of views with colonists, Americans, and foreigners, on the subject of international patent law and other subjects of interest to inventors.

The institute is also intended to constitute a channel for facilitating the combination of inventors, manufacturers, and those interested in trade, in order to organise united action with respect to the changes still desirable in the Patent Law. . . .

An international exhibition of inventions is to take place at South Kensington in 1885, and inventors who intend to take part in it will do well to avail themselves of the advantages of this institute.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JULY 2.		BUSINESS DONE WEEK ENDING JULY 2. Highest.	Lowest.
Anglo-American	31,	32	32	31⅝
Do. Preferred	55,	56	56	55⅝
Do. Deferred	6½,	7	—	—
Brazilian Submarine	9⅝,	9⅞	9⅞	9 13-16
Cuba	9¾,	10¼	—	—
Do. Preference	16½,	17½	17¼	—
Direct Spanish	4½,	5	—	—
Do. Preference	14¼,	14¾	—	—
Direct United States Cable	9⅜,	9⅝	9⅝	9⅜
Eastern Telegraph	10⅞,	11⅛	11⅛	10 15-16
Do. 6 per Cent. Preference	13¾,	14¼	14	13½
Do. 5 per Cent. Debentures, 1899	103,	107	—	—
Eastern Extension	11⅜,	11⅝	11 9-16	11 5-16
German Union	9¼,	9¾	—	—
Globe Telegraph and Trust	6½,	6¾	6 11-16	6½
Do. Preference	12⅜,	12⅝	12½	12¼
Great Northern	13⅝,	13⅞	14 1-16	13 15-16
Indo-European	30,	31	31¼	—
Mediterranean Extension	1¼,	1¾	—	—
Do. Preference	2,	4	—	—
Reuter's	8,	8½	—	—
Submarine	156,	158	156	152
West India and Panama	⅜,	⅞	—	—
Do. 1st Preference	6,	6½	—	—
Western Brazilian	4⅞,	5⅛	5⅛	5
Western Union 7 per Cent. 1st Mortgage	121,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	106	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	3-16,	5-16	¼	—
Oriental	⅛,	⅜	5-16	—
United Telephone	9½,	10	10¼	9 11-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1½,	1¾	1⅝	1½
Do. (fully paid)	3,	3½	3⅜	3
Hammond Light (£3 15s. paid)	⅜,	⅝	½	7-16
Eastern Electric (£4 paid)	—	—	—	—
Swan	¼,	½	⅜	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	30½,	31½	31⅝	30½
India Rubber, Gutta Percha, and Telegraph Works	20½,	21½	20½	—

TRAFFIC RECEIPTS FOR JUNE, 1884.

COMPANIES.	June, 1884.	June, 1883.	Increase.	Decrease.
Cuba Submarine	3,150	2,688	462	—
Direct Spanish Telegraph	1,345	1,556	—	211
West Coast of America	3,015	—	—	—
Western and Brazilian	—	—	—	—

THE EASTERN TELEGRAPH COMPANY, LIMITED.

NOTICE IS HEREBY GIVEN that the TWENTY-FOURTH HALF-YEARLY ORDINARY GENERAL MEETING of the EASTERN TELEGRAPH COMPANY (Limited) will be held on THURSDAY, the 10th JULY, 1884, at ONE o'clock in the afternoon, at the CITY TERMINUS HOTEL, Cannon Street, London, when the Directors' Report and Accounts, for the half-year ended 31st March, 1884, will be presented, a Dividend declared, and the ordinary business of the Company transacted.

NOTICE is also given that the Register of Transfers will be closed from the 8th to the 15th July, both days inclusive.

By order of the Board,
GEORGE DRAPER,
Secretary.

London, 1st July, 1884.

WANTED.—A STUDENT or ENGINEER to join Advertiser, once a week or oftener, in reading Dynamo Machine Literature.—J. W., 50, Spencer-street, Goswell-road, E.C.

A WELL-KNOWN ELECTRICIAN is open to ENGAGEMENT. Long experience in Electric Lighting, Accumulators, Plating, and Cable Work. Good engineer.—Address, L. T., at C. H. May and Co.'s General Advertising Offices, 78, Gracechurch-street.

EXPERIENCED MECHANICAL ENGINEER and ELECTRICIAN seeks EMPLOYMENT. Well educated. Has had charge of important installations of Electric Light.—Address, A. B., *The Electrician* Office.

FOR SALE.—A Post Office Pattern WHEATSTONE BRIDGE (Elliott); quite new. Cost £26. What cash offers?—Address, H. A., *The Electrician* Office, 1, Salisbury-court, Fleet-street.

FOR SALE.—50 Lane-Fox SECONDARY BATTERIES and about 200 De Kabath ACCUMULATORS.—Apply to THE ELECTRIC LIGHTING SUPPLY AND FITTING COMPANY (Limited), 28, York-street, Westminster, S.W.

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NOTES.

Electric Lighting in Theatres.—The Wilhelm Theatre at Cologne is to be lighted by electric lamps.

Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending 4th July were £2,524.

Earthquake in India.—Indian papers report that several smart earthquake shocks were felt at Delhi between eleven and three p.m. on June 6.

Electric Lighting at Brighton.—The Orleans Club, Brighton, has been re-opened, and the principal rooms are now lighted with electric lights.

Kelway's Electric Log Syndicate.—Mr. Justice Kay has made an order for the voluntary winding up of this syndicate to be continued under the supervision of the Court.

St. George Telephone Company.—Creditors of this company should send their names and claims before August 19 to Mr. George Boggis, 14, St. Swithin's-lane, E.C., the official liquidator.

Eastern Extension Telegraph Company.—The traffic receipts of this company for the month of June, 1884, amounted to £31,787, and to £34,307 for the corresponding period of 1883.

Weather Telegrams in Victoria.—The Melbourne Observatory is, says *The Colonies and India*, making arrangements for supplying complete weather information to the country townships.

New Knight.—Her Majesty has been pleased to confer the honour of knighthood upon Professor Roscoe, F.R.S., in consideration of the services rendered by him in connection with the Technical Commission.

Rysselberghe's System of Telephony.—M. Cochery, the French Minister of Posts and Telegraphs, has allowed experimental trials of this system to be made on the telegraph line between Rouen and Havre.

The "Illustrated Science Monthly."—This magazine for July contains an article by Mr. G. W. von Tunzelmann on "Matter and Motion," and an interesting biography of Professor John Tyndall, F.R.S., with a portrait.

"L'Electricite."—After a somewhat chequered career our contemporary *L'Electricité* appears in new shape, with a new editor and apparently new proprietors. The management and direction is now in the hands of Dr. C. C. Soulages.

Cable Extension.—It is notified that the Eastern Extension Company's system has been extended to Macao by the laying of a submarine cable between that place and Hong Kong. The tariff from all stations in Great Britain is 8s. 9d. per word.

West Coast of America Telegraph Company.—At a meeting of the directors of this Company on Wednesday a dividend was declared of 4s. per share on the £10 shares, or at the rate of 4 per cent. per annum for the half year ending June 30 last.

Royal Assent.—On the 3rd inst. Royal assent was given by commission to the following Acts:—Electric Lighting Order Confirmation (No. 3) Act, 1884; ditto, ditto (No. 4) Act, 1884; India Rubber, Gutta Percha, and Telegraph Works Company Act, 1884.

Globe Telegraph and Trust Company.—This company announces a dividend of 3s. per share on the Preference shares, making a total for the year of 6 per cent.; and 3s. 6d. per share on the Ordinary shares, making a total dividend for the year of 4¾ per cent.

New Cable.—The managing director of the Brazilian Submarine Telegraph Company announces the successful laying of the second cable between St. Vincent and Pernambuco, thus completing the duplication of this company's entire system between Europe and South America.

Great Northern Telegraph Company.—The traffic receipts of this company for June, 1884, were £22,960; for the period January 1st to June 30th, 1884, they were £129,520, against £123,488 for the corresponding months of 1883, and £116,527 for the same period of 1882.

Electric Light in Manchester.—The contract for the lighting of the Clarence Hotel has just been placed with Mr. F. D'A. Goold, electrical engineer and contractor, of Manchester. The plant will consist of the necessary machinery for running 200 incandescent lamps.

Hotel Lighting.—The Waterloo Hotel in Manchester is to be lighted with the electric light. The work, which will comprise 200 incandescent lamps, has been placed in the hands of Mr. F. D'A. Goold, electrical engineer and contractor, 29, Arcade-chambers, St. Mary's Gate, Manchester.

South Eastern Railway Company—The Anglo-American Brush Corporation are opposing this company's (various powers) Bill, as, amongst other things, it seeks power to acquire land on which the corporation's works are situate for the purpose of widening the line at Charing Cross.

The Telephone for Mines.—The telephone is extensively used in the mining regions of Silesia. Several mines and factories are connected up to a central office at Benthuen. There are 112 subscribers, and the length of lines is 1,180 kilometres. The number of calls per day is over 322.

Mediterranean Extension Telegraph Company.—The liquidators of this company have been notified that the Bill authorising the transfer of the undertaking to the Eastern Telegraph Company has received the assent of both Houses of Parliament, and merely awaits the sanction of the King.

Faure Electric Accumulator Company.—At a meeting of this company, held on Tuesday, the resolutions for winding up the company voluntarily were confirmed, and Mr. Francis Cooper (Cooper Brothers and Co.), Mr. Herbert Canning, and Mr. Richard Alexander Brown were appointed liquidators.

An American Exhibition.—The idea of holding an exhibition of American manufactures and arts in London has been started. It is proposed to open the exhibition on 1st May, 1886. Mr. J. R. Whitley is the general director in London, and Mr. C. B. Norton is the secretary. The offices are at 7, Poultry, E.C.

Telephone Company of Ireland.—This company is inviting subscriptions for 5 per Cent. Preference Shares, payable 5s. per share on application, 5s. on allotment, and the balance as may be required at intervals of not less than three months, with power to the company to redeem the same at a premium of 10 per cent.

Ship Lighting.—The "Banshee," the latest addition to the London and North Western Railway Company's fleet of

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boats for the Irish Channel service between Dublin and Holyhead, is lighted by incandescent lamps. She is a paddle steamer of 1,780 tons, and 3,500 indicated horse-power, and has been built by Messrs. Laird, of Birkenhead.

STENO TELEGRAPHY.—We have received from M. Cassagnes, C.E., a little pamphlet bearing this title, in which is a description of his proposed method of telegraphing shorthand, his idea being that reporters' shorthand notes of speeches, &c., can be telegraphed straight to the papers and transcribed in their offices, thus saving them much time and money.

NEW SHIP.—The Italian Royal Mail steamer "Regina Margherita," 3,700 tons, was launched on Wednesday from the building yard of Messrs. M'Millan and Son, Dumbarton. Her extreme length is 415ft., breadth 42ft., and depth 29½ft., and she has a promenade deck her whole length, 8ft. 6in above the main deck. She is to be lighted with the electric light throughout.

THE NEW BENNETT-MACKAY CABLE. — The steamship "Faraday" has picked up the buoy of the south cable she recently laid on completing the shore end of the cable at Waterville, about 200 miles from the Irish coast, and had on Tuesday paid out a further portion of cable to the extent of 250 miles. This makes about 450 miles paid out from the Irish coast. The weather is splendid for cable operations, and the work is expected to be shortly completed.

ELECTRIC LIGHTING IN MELBOURNE.—The Anglo-American Brush Electric Light Corporation have received a large order from the Australian Electric Light, Power, and Storage Company, for electric lighting apparatus. The machines ordered are five Victoria machines of the size known as the F_2 250 lighter, and one 100-light D_2 machine, together with a large number of Victoria incandescent lamps. This plant or the greater part of it will be used for working the electric light to be installed in the Parliament Houses of Melbourne.

TELEGRAPH EXTENSION IN ORKNEY.—In the House of Commons on Thursday, the 3rd inst., Mr. Courtney, replying to Mr. Barclay, said that the main recommendations of the Crofters' Commission in favour of increased telegraphic facilities in Orkney and Shetland had already been anticipated under an arrangement with the Fishery Board. Looking to the unremunerative character of the telegraph service at home, it was scarcely possible to dispense with the guarantee now required before providing such telegraphic communication.

MANGANESE MINES IN NOVA SCOTIA.—Some interesting information has recently been given before the Royal Society of Canada regarding the manganese mines of Nova Scotia. It was stated, as a result of surveys and investigations, that the manganese ores of this province occur low down in the carboniferous limestone, below the gypsum deposits characterising that stratum, and that they are connected with limestones frequently manganiferous, and usually so magnesian as to approach dolomites in composition. The ores are, it is found, of unusual purity.

ELECTRIC LIGHTING IN FINLAND.—Messrs. Astrom Brothers, of Ulealong, Finland, are about to light their tanneries by incandescent lamps, and have placed the order for the necessary apparatus in the hands of the Anglo-American Brush Corporation. The plant will consist of one D^2L Victoria dynamo, compound wound, for eighty 20 candle-power and eighty 10 candle-power Victoria lamps, together with the necessary fittings and cable. The whole of the work will be superintended and carried out by the Corporation, who are about to send one of their assistant engineers to Ulealong for that purpose.

ELECTRIC LIGHTING IN BELFAST.—On the occasion of the ball given in honour of the recent visit of his Excellency Earl Spencer, K.C.B., to Belfast, the lighting of the Ulster Hall was effected by electric lamps. The main hall was illuminated by six arc lamps of the Newton type, while the vestibule and staircases were effectively lit by means of Swan incandescent lamps to the number of about 40, tastefully arranged on existing and special fittings, or in hanging baskets of flowers and ferns. The entire work was carried out by the Belfast Electric Appliances Company, under the supervision of their manager, Mr. Geo. Annesley Grindle.

TELEGRAMS AND THEIR USE.—"M." writes to *The Times* of July 9:—"Last evening (July 3) an important telegram was handed in at the House of Commons office at 8 o'clock. It reached me in Cornwall-gardens a few minutes after 9. To-day I myself put in one at the same office, which it was equally important should reach the City in a few minutes. The clerk retained it in his hand and went on receiving others. I begged him at least to hand mine to the operator, whereupon he calmly replied, 'Oh, that is no use; there are several before yours.' I took it and my money back, and sent a messenger. If this sort of thing can happen from important centres, is not telegram sending rather a farce?"

MAXIM-WESTON ELECTRIC COMPANY—A notice has appeared in the *Gazette* to the effect that the order of the High Court of Justice, dated 14th June, confirming the reduction of the capital of the above company from £500,000 to £250,000, and the minute showing the particulars required by law were registered on the 2nd July. The minute reads as follows:—"The capital of the Maxim-Weston Electric Company is £250,000 divided into 500,000 shares of 10s. each. At the time of the registration of this minute 200,000 of the shares have been issued, of which 190,000 are deemed to be fully paid up and 2,000 of such shares are deemed to have 19s. per share paid up thereon, and the remaining 300,000 have never been issued."

REMARKABLE FEAT IN TELEGRAPHY.—"J." writes to *The Times* of July 4 as follows:—"On Tuesday last I sent a telegram from East Croydon to Westminster at twenty minutes to 10 a.m., and it positively reached its destination at Bridge-street seven minutes under the hour—*i.e.*, at 10:33. I arrived there myself (by train) at ten minutes past 10, and thus I was enabled with a little patience to witness the arrival of my own telegram twenty-three minutes later. A few days ago I sent a telegram from East Croydon to Brighton, and that arrived almost in the same time. If things go on at this rate I would suggest the desirability of some one presenting a testimonial to the telegraphic authorities in order to stimulate them to still greater exploits."

SUBMARINE EXPLORATION.—M. Toselli has designed a kind of magnified diving bell, containing three different chambers, which can be let down into the sea from a vessel for submarine exploring purposes. It is formed of a steel cylinder some ten metres long and three metres diameter, fitted with a winding staircase leading down through the different compartments. It is of course air tight, and is supplied with two reservoirs of compressed air for the explorers. Telegraphic and telephonic communication is provided to facilitate communication with the ship, and the three compartments are all lighted by incandes-

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cent lamps. The bottom compartment is fitted with a number of windows through which the observers can investigate their marine surroundings. An experimental trial at Nice has given good results, and we believe the designer intends building a still larger apparatus for exploring the sea at greater depths. Messrs. Imbert Bros., of Nice, are the constructors of his first apparatus, which he has named the "Neptune."

INDUCTION ON UNDERGROUND AND OVERHEAD WIRES.—This subject was dealt with by Mr. F. N. Gisborne, in a paper read at the annual meeting of the Royal Society of Canada, held at Ottawa at the end of May. The author proposed to get rid of induction effects in telephone circuits by connecting the sending and receiving telephones by means of pairs of twisted and insulated wires. He described experiments made with a section of cable about 3,000ft. in length and laid underground between two of the departmental buildings at Ottawa. The cable contained 20 indifferently insulated wires, which were divided into pairs, two wires being twisted together in each case, each pair constituting a metallic circuit, and one wire of each pair being used as a "return" instead of the earth plates usually employed. The experiments showed that if one of these pairs was used as a telephonic circuit, no induction effects could be observed in the others. The absence of induction he attributed to the equidistance of the two wires of a pair from any third wire and the equality and opposition of the currents flowing in them.

MILL LIGHTING.—Mr. J. F. Milner, proprietor of the Woodside Mill, Elland, Yorks, has introduced the incandescent system in his mill. The installation consists of one Crompton Burgin compound self-regulating dynamo machine and some 76 20 candle-power Swan incandescent lamps. It is intended to add to the number of incandescent lamps on the completion of Mr. Milner's new offices. It is also intended that there shall be an arc lamp on each side of the mill for loading purposes; these will be of the well-known Crompton-Crabbe double differential type. The dynamo is placed on the top floor, where it is driven by a small separate engine, which, although intended to drive the hoist, answers admirably for driving the lights, as it can always be kept running if desired. It is driven by a countershaft at a speed of 1,400 revolutions per minute. The E.M.F. at the terminals of machine and lamps is 110 volts. The work has been carried out under the superintendence of Mr. J. T. Baron, on behalf of Mr. Wilson Hartnell, electric light contractor, of Leeds. Mr. Hartnell's success in mill lighting is without doubt due to the care with which he carries out his installations. In his hands the electric light should gain the prestige which it has lost in some instances by reason of the carelessness and incompetency of the men who have had the working of it.

OVERHEAD WIRES.—In the *Pall Mall Gazette* for Tuesday last Professor Silvanus P. Thompson writes on this subject. Those best qualified to speak on the subject from long experience agree, he says, that the life of every wire is limited, and none can tell how or when a wire may snap. The internal flaws do not reveal themselves when the line is erected, nor can they be detected after the line has been put up except by the actual breaking of the line. Professor Hughes has established the fact that every vibration imparted to a wire brings it a stage nearer to a state of internal crystallisation, when it snaps short, its fibrous structure having completely degenerated. Most of the existing telephone wires are only five or six years old; another five years and there will be a fine crop of accidents to report. Common sense suggests as the obvious remedy that already adopted in other great cities, namely, the laying of the wires underground in proper channels under the road or kerbway. The somewhat greater prime cost of doing this would be met in a very short time by the counter gain in having practically no renewals or repairs, and no deterioration of any moment in the wires laid underground. It would take an earthquake to dislocate or break them. Professor Thompson thinks there can be no doubt which way public opinion is tending, and exclaims as he lays down his pen, "Let us be wise in time."

A NEW SYSTEM OF PAINTING IRON.—A process, on a new principle, for protecting iron and steel from corrosion (especially when submerged) has been patented by Mr. F. Maxwell-Lyte, F.C.S. The theory of the process, says a contemporary, is essentially electrical, and its utility is based upon the hypothesis that the oxidation of iron and steel is much accelerated by, if not wholly due to galvanic action. The metal to be protected is first coated with one or two primings of an oxide of a metal electro-positive to iron, upon which any of the ordinary anti-fouling or oxide paints may be applied. These latter always contain the oxide of a metal electro-negative to iron, and this oxide will consequently always be reduced, and the iron oxidised in time. The priming employed by Mr. Maxwell-Lyte is composed of oxide of zinc or magnesia, particularly the latter; and this not only protects the iron, but keeps it from contact with the outer coat. It is claimed that something of this kind has always been used whenever painting of iron has been even partially successful; but that the guiding principle—the use in the first place of a material electro-positive to iron—has been overlooked. Red lead as a priming does fairly well for a time, because though lead is electro-negative to iron it is only slightly so. Better protection is assured by the use of a distinctly basic material.

UNDERGROUND WIRES FOR NEW YORK.—The following is the text of the law requiring telegraph and electric light wires to be put underground in cities of more than 500,000 inhabitants in the State of New York:—Section 1. All telegraph, telephonic, and electric-light wires and cables used in any incorporated city of this State having a population of 500,000 or over, shall hereafter be placed under the surface of the streets, lanes, and avenues of said cities. Section 2. Every corporation, association, or person owning or controlling telegraph, telephonic, electric, or other wires and cables, including what is known as telegraph-poles, and other appurtenances thereto, shall, before the 1st day of November, 1885, have the same removed from the surface of all streets or avenues in every such city of this State. Section 3. In case the owners of the property above enumerated shall fail to comply with the provisions of this Act within the time herein specified and limited, the local governments of the said cities of this State shall then, and they are hereby directed to remove, without delay, all telegraph, electric-light, and such other wires, cables, and poles, wherever found above ground, within the corporate limits of their respective cities. Section 4. No city in this State shall grant any exclusive privilege or franchise under this Act to any corporation or individual by which a monopoly may be created or competition prevented on equal terms. Section 5. This Act shall take effect immediately.

SULPHATE OF COPPER SOLUTIONS.—Professor J. G. MacGregor has been making extended researches on the density and thermal expansion of aqueous solutions of copper sulphate, and communicated the results of his investigations

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in a paper read at the annual meeting of the Royal Society of Canada, recently held at Ottawa. He finds that the rate of variation of density with temperature increases with the temperature and with the percentage of salt in solution; that the density of any solution at low temperatures (below 20° C.) diminishes, as the temperature increases at a greater rate than that of water; that the ratio of the density of a solution to the density of water at the same temperature diminishes as the temperature increases; and certainly for many solutions, probably for all, attains a constant value within the temperature limits of the experiments (below 35°-50°); that, therefore, at about 40° C. the thermal expansion of solutions is the same as that of water at the same temperature. The experiments also substantiated a result formerly reached by Professor Ewing and the author, that very weak solutions of this salt have a smaller volume than the water used in making them. If then these solutions are made by the addition of anhydrous salt to water, contraction must occur. The experiments show that the greatest contraction occurs in the case of a solution containing 1·34 per cent. of anhydrous salt, in which case the contraction is 0·0048. The solution containing 5·95 per cent. of anhydrous salt has the same volume as the water required to make it.

PYRO-ELECTRIC PROPERTIES OF BORACITE.—The optical, thermic, and pyro-electric properties of boracite have been the subjects of a series of investigations by Hauy, Hankel, Mallard, Baumhauer, and others. Herr Mack has recently made researches based upon an observation of Kundt that Lichtenberg's figures can be used for an examination of the pyro-electric properties of crystals. A description of his experiments appeared in *Wiedemann's Annalen*, Vol. XXI., pp. 410 to 421, and the following abstract is given in the Chemical Society's *Journal* for June :—"The method of observation consisted in heating the crystal to be examined in an air bath, removing it by a pair of pincers previously heated in the same bath. The crystal is then passed through an alcohol flame and placed on a slip of wood or paper, where it is dusted thoroughly with the ordinary mixture of sulphur and red lead. On cooling, the particles of these substances arrange themselves in definite lines, thus marking out the field of positive and negative electricity. The crystals examined were cubical, rhombic, dodecahedral, and tetrahedral, obtained from Stassfurt and Luneberg. The general results of the investigation may be summed up as follows: 1. The difference of potential, whether positive or negative, does not extend over the whole surface of a crystal, but follows certain definite lines. 2. If upon a crystal, in which either the rhombic or dodecahedral form is dominant, there be conceived to be marked out a smaller, perfect rhombic dodecahedron, so that its principal crystallographic axes coincide with those of one or other of the above crystals, and there be projected from the common middle point, the angle of the latter dodecahedron upon the surface of the crystal, then a system of lines is obtained, coinciding with the lines of the electro positive or negative potential differences. Those lines which connect the middle points of smooth and glistening tetrahedral surfaces are coloured yellow, but those which lie symmetrically to any principal symmetrical plans of the regular system are red. This system of lines coincides with the optical system of lines of double refraction which have been described by Klein and Baumhauer. It would appear, then, that there is an intimate connection between the optical and pyro-electric properties of boracite. The former are probably conditioned by a state of tension of crystal, and the experiments of T. and P. Currie would seem to point to the same conditioning of the pyro-electricities.

ELECTRIC LIGHTING AT THE HEALTH EXHIBITION.—A large part of the grounds and buildings of the Health Exhibition at Kensington are being illuminated by arc and incandescent electric light apparatus, supplied by the Anglo-American Brush Corporation. The number of arc lights used is 25, that is including the two lamps in parabolic reflectors used for throwing the rays of light on to the central fountain when working, which are fixed on the central gallery. These 25 lamps are of the well-known Brush arc type, 23 being the ordinary 2,000 candle-power type, and the two in the reflectors the automatic lamps used for head lights on ships. For indoor use the lamps are fitted with ornamental brass covers, and crowns are placed in hexagonal lanterns in the grounds. The machine driving these lamps is, however, the chief feature of this exhibit. It is a No. 7 Brush 16-light sized machine, but is fitted with Mr. Brush's new patented armature, which is the property of the corporation. This new improvement renders the machine capable of running half as many lights again as when fitted with the old form of armature. The machine at the Health Exhibition is never running less than 23, and often 24 lamps, with the same degree of brilliancy as it used to run the 16 with the old armature. A remarkable feature in this armature is that it keeps cool when the machine is working, and remains so even after a long run. Some of the portions of the Exhibition lit by the company's arc lamps are the East and West Annexes, the Central Annexe, Clements & Co.'s stand, &c. Their incandescent lamps will be found at the exhibit of the Dowson Economic Gas Company, a compound D_2 Victoria machine being used, with about 100 20 candle-power Victoria lamps for lighting the exhibit. The machine is driven by one of Messrs. Crossley's new double cylinder Otto engines, and the gas for driving it is made by the gas company's plant there. In the electric light machinery shed there is a D_2 Victoria machine, driven by means of a Parson's high speed direct acting engine, which is remarkable for silence and freedom from vibration in working. The Victoria machine operates some 100 lamps of 100 volts, placed in Lockhart's Cocoa Rooms, some being used in the refrigerating chambers in the Western Annexe. Another D^2 machine, similarly wound to that in the electric light shed, is about to be placed there for driving a number of incandescent lamps. This machine will be driven by a Tower spherical engine, made by Heenan and Froude, of Manchester.

ELECTRICITY APPLIED TO WEAVING.—The late Comte T. du Moncel contributed an interesting article on this subject to the paper with which he was connected, and an abstract has been published in the "Abstracts of Papers in Foreign Transactions, &c.," published by the Institution of Civil Engineers, as follows:—"Of the various applications of electricity, none have progressed more slowly than that which was made nearly thirty years ago in the weaving shed. The journals of 1855 and 1856 were full of the marvellous results furnished by this application, which was to supersede the Jacquard looms by substituting electric interruptors for the Jacquard cards. The author first deals with the Bonelli system, and to make his description clear he explains the principle of the Jacquard loom. In the Bonelli system, the lower part of the Jacquard loom is maintained, but the crotchets are terminated in an iron head resting on a tringle or bar of wood connected to the pedal. This tringle, or these tringles, for there are several, are, by the pedal, raised to the height of one or several series of straight electro-magnets in number equal to the crotchets. A metallic cylinder, or an endless metallic cloth working on two cylinders, together with a series of points communicating with the electro-magnets, constitute the means of making and

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interrupting contact and controlling the displacement of the crotchets. The design is traced in insulating parts and in conducting parts on the cloth or cylinder, and such an arrangement for only two colours is extremely simple; but for more highly-charged designs, such as cashmeres, Bonelli constructed a special transmitting apparatus. This is composed of two parts, a grated composing frame and a comb with movable teeth. There is also a frame in which are ranged, according to the different shades of colours and the space these should occupy, small pieces of metal of different lengths (varying according to the order of the colours) and of different widths (varying as to the space these should occupy on the design). These pieces are of the same thickness. Over them, constituting an unequal face, are passed the movable teeth of the comb. As the teeth of the comb are each in connection with one of the electro-magnets of the loom, at each movement of the pedal the crotchets related to each colour are raised at the same time. In Maumene's system the electro-magnets are caused to act directly on the needles, which in the ordinary Jacquard loom uphold the crotchets. By this arrangement the ordinary machine is preserved nearly intact. A cylindric commutator is employed. In Pascal and Mathieu's system a plate of copper that has received the design is placed vertically and laterally with relation to the crotchets sustaining the threads. It turns on a cylinder without total displacement. In Gand's system the electro-magnets act directly on the crotchet bars, and fixed conducting wires are substituted for the movable needles of the Jacquard loom, which are subject to frequent disarrangement. And instead of the Jacquard cards paper bands are employed placed over a polygonal frame. Regis's system is a modification of that of Gand. A later system by Bonelli discards the commutator, or rather substitutes an inverse arrangement, and instead of making a conducting surface insulating, an insulating surface is metallised. In the former case the insulating material wore away and clogged the contact brush. The designer draws on paper with the aid of a sticky varnish the pattern to be produced in the tissue. The design is then covered with a sheet of tinfoil, which is allowed to remain in contact for about half an hour. The paper is then rubbed with a cotton pad, the tin remaining adherent where the varnish is, and elsewhere disappearing. The author appeared to be of opinion that further valuable improvements are to be anticipated.

THUNDERSTORMS.—The hot weather of the past few weeks has had its natural termination in a series of violent thunderstorms, which have caused considerable damage to property and resulted in the loss of several lives throughout the British Isles. On Friday, the 4th instant, a horse was killed by lightning while grazing in a field at Barrowford, near Burnley, Lancs., and two men who were sitting near were struck, but were not killed. At Northampton on the same day several houses and a factory were damaged by lightning. Two men at work in a field at Aston, near Wallingford, Berks, were killed, their clothes being burnt off their bodies; a horse was also struck and killed. Near Wymeswood, on the same day, viz., Friday, two brothers and their nephew at work in a hayfield took shelter under a hedge, and were all struck by lightning. According to a report of the occurrence in the daily papers the nephew felt a sharp pain on the thigh and became senseless. On recovering he found that one uncle had fallen and the other was sitting, looking placid and apparently undisturbed, but on examination he found both were quite dead. The storm was exceptionally violent in the Loughborough and Charnwood Forest district, and it is feared the damage is considerable. In Scotland also the storm was severe, houses being struck in Forfarshire, Perthshire and Fifeshire. On Saturday Holy Trinity Church, Everton, Liverpool, was struck by lightning, two boys within the building being seriously hurt, and the congregation thrown into panic. A stable on the farm of Sir B. Bridges, at Goodnestone, was set on fire by the lightning, and three valuable horses were burned to death. At Cambridge a woman was killed and two or three buildings set on fire by the flashes of lightning. A Wesleyan chapel at Lane Head, Weardale, Durham, was struck and two men were injured. In the island of Skye several houses were damaged, and at Fort William a young man was killed by lightning. At Edinburgh on Friday a remarkable phenomenon was observed. A thunderstorm came on at the time of a rather dense fog, which had for some days been hanging over the east coast of Scotland. The lightning flashes, which were extremely vivid, produced, it is said, a weird effect in illuminating the foggy atmosphere. The Coroner for North Oxon held an inquest on the body of William H. Smith, a painter and landowner, who was killed during a thunderstorm at Deddington on Friday. The deceased was taking shelter under a tree, and was about to partake of dinner, which his wife had just brought him, when the lightning struck him and killed him instantaneously. The wife felt the shock, but was not seriously injured. A verdict of killed by lightning was returned. During the thunderstorm which swept over the district of Consett on Sunday afternoon, Thomas Gill, a miner, who was nursing an infant on his knee, was struck by lightning and killed. The child escaped. The house and furniture were much damaged. The storms continued through Monday, Tuesday, and Wednesday. On Tuesday a cottage was fired at Preston, Lancashire, and it was reported that several persons had been struck by the lightning. At Crewe a boy named William Edward Morris was killed whilst returning from cricket; his face, shoulder, and right side were much burned, his clothes torn, and both his boots were ripped from his feet. Houses were damaged, and several persons had narrow escapes. At Coventry the lightning struck a man insensible, but he is expected to recover. On Wednesday a storm, accompanied by heavy rain, and some snow and hail, passed over Oldham, and two gangers who entered a hut for shelter, near to the Royton Spinning Company's new lodge, were killed, and three or four others more or less injured. At Preston buildings were struck and cattle killed. A severe storm broke over Leeds about six o'clock. Hailstones of an extraordinary size fell, and much damage was caused by the heavy downpour of rain. In the district of Retford 30 sheep, the property of a farmer named Twidale, of Upton, were killed whilst sheltering beneath a tree, and two cows—one at West Drayton and the other at East Markham—were struck whilst grazing in the fields. A storm also broke over Warwickshire, Leicestershire, and the central Midland districts. Two beasts were killed in a field near Heather, and at the village of Kersley twelve sheep were destroyed. Trees were split, chimney pots were shattered in all directions. At Rothwell a man named James Hainsworth, an engine-driver at the collieries, was struck dead by lightning whilst on his way home from work, and two of his companions were rendered insensible. In Hertfordshire the storm was very severe. As Mr. Judson, a farmer of Kilton-in-Cleveland, was carting hay on the same day (Wednesday), assisted by three of his men, all four were struck by lightning, and rendered temporarily blind. At Bramley Station (Yorkshire) the lightning set fire to the roof. It may be remarked that the barometer appears to have remained remarkably steady during these storms.

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ELECTRO-CHEMISTRY.—Inorganic.

BY DR. G. GORE, F.R.S.

(CONTINUED FROM PAGE 174.)

Electrolysis of Sodium Carbonates.—Na_2CO_3 and $NaHCO_3$. According to Favre and Roche, by electrolysis, neutral sodium carbonate splits up into $CNa.O_3$ and Na., the sodium being oxidized by the water with separation of hydrogen. The acid carbonate is resolved into Na and CHO_3, the sodium being then oxidized and hydrogen evolved; the $2CHO_3$ is then resolved into $2\ CO_2 + H_2O + O$. According to Burckhard, sodic carbonate in a state of fusion is a good conductor, and is decomposed by electrolysis into carbonic acid at the anode, and soda together with a little carbon, at the cathode (*Chem. News*, Vol. XXI., p. 238).

Electrolysis of Biborate of Sodium.—Fused borax yields oxygen gas at the anode and boron at the cathode. The boron is separated by indirect action; the current resolves the soda into oxygen and sodium, and the latter separates boron from the boracic acid (Faraday, Gmelin's "Handbook of Chemistry," Vol. I., p. 460). Burckhard states that fused borax conducts, suffers electrolysis, and a series of compounds are formed or volatilised; but the chief result is that the salt is decomposed into soda and boron at the cathode and oxygen at the anode (*Chem. News*, Vol. XXI., p. 238).

Electrolysis of Sodic Sulphate. — Na_2SO_4. Molecular weight = 140. By the electrolysis of this salt in a fused state with platinum electrodes, sodium is deposited and combines with the cathode (Brester, *Chem. News*, Vol. XVIII., p. 154).

From the results obtained by electrolysing sulphide of sodium, Buff concluded that all the sulphur travelled to the anode and the sodium towards the cathode (*Chem. News*, Vol. XV., p. 279).

Electrolysis of Diphosphate of Sodium.—Na_2HPO_4. A solution of this substance is decomposed by a separate current into phosphoric acid at the anode and soda at the cathode. According to Faraday, acid phosphate of sodium in a state of fusion yields hydrogen at the cathode (Gmelin, "Handbook of Chemistry," Vol. I., p. 460). According to Burckhard, fused pyrophosphate of sodium, electrolysed with platinum electrodes, yields phosphide of platinum; but the chief result is that the salt splits up into oxygen, phosphorus, and soda (*Chem. News*, Vol. XXI., p. 238).

For the reducing action of sodium amalgam on solutions of silver, mercury, iron, and chromium, see the sections relating to those metals; also Watts's "Dictionary of Chemistry," Vol. VI., p. 816. For Jablockhoff's process of making sodium by electrolysis, see *Scientific American*, Sept. 22, 1883, p. 643.

Separation of Potassium.—K. Electro-chemical equivalent = 39·1. A monad cation. Magnesium, by simple immersion in a solution of potassic dichromate, forms potassic hydroxide (S. Kern, *Jour. Chem. Soc.*, 1876, Part II., p. 479). Zinc amalgam immersed in a solution of caustic potash liberates pure hydrogen (Watts's "Dictionary of Chemistry," Vol. III., p. 891). According to W. Skey, an aqueous solution of potassic chloride becomes alkaline by contact either with zinc or with silver, in the first case, probably by decomposition of water and formation of ammonia, aided by formation of zinc oxide, and in the second by oxidation of the silver by free oxygen, and the subsequent decomposition of that oxide with formation of silver chloride and caustic potash (*Jour. Chem. Soc.*, 1876, Part II., p. 266). Both carbon and iron separate potassium from melted potash at a white heat, and the process for obtaining potassium is based upon this fact. Brester states that even silver will dissolve in large quantities in melted potassic hydrate (*Chem. News*, Vol. XVIII., p. 145), and I have observed that when this hydrate is melted in a pure silver crucible the vessel loses in weight.

Electrolysis of Potassic Hydrate.—KHO. Molecular weight = 56·1. Potassium was first separated by electrolysis in the year 1807 by Sir H. Davy. He moistened a piece of potassic hydrate with water, placed it in a platinum capsule, which acted as a cathode, and touched the hydrate with the platinum wire anode of a battery of from 100 to 200 of Wollaston's cells. The potash liquefied, and globules of the metal separated at the cathode. Since that time it has been found that even a feeble voltaic current will liberate potassium from aqueous solutions of some of its salts, and if the deposited metal is protected from oxidation by being deposited into a cathode consisting of a large bulk of mercury with but a small portion of its surface exposed to the liquid, the potassium can be obtained in the form of its amalgam.

When mercury is placed in a cup connected with the cathode of a voltaic battery of at least 20 pairs, and covered with a strong solution of caustic potash, in which a piece of that substance is immersed, and into which the anode dips, the mercury takes up potassium (Berzelius, Watts's "Dictionary of Chemistry," Vol. III., p. 889).

According to Janeczek, when melted potash is electrolysed oxygen is evolved at the anode and potassium at the cathode, but no hydrogen; but if the experiment is made in a closed apparatus, after some time it is found that water is evolved with the oxygen, and some hydrogen is also set free; the latter probably results from the action of the potassium upon the melted alkali (*Jour. Chem. Soc.*, 1876, Part I., p. 182; also Watts's "Dictionary of Chemistry," Vol. VIII., Part I., p. 709).

Brester states that in the electrolysis of melted caustic potash an anode of either platinum, silver, or copper dissolves in the liquid, and the respective metals are deposited upon the cathode (*Chem. News*, Vol. XVIII., p. 145).

Electrolysis of Potassic Nitrate.—KNO_3. Molecular weight = 101·1. Some information has already been given of the effects of an electric current upon this compound (*see* "Electrolysis of Oxides of Nitrogen"). According to Faraday, an aqueous solution of it conducts electricity very easily, and yields hydrogen at the cathode.

Electrolysis of Potassic Fluoride. — KF. Molecular weight = 58·1. Fremy electrolysed fused potassic fluoride, and obtained a gas which rapidly attacked platinum, decomposed water, with formation of hydrofluoric acid, and displaced iodine from metallic iodides (Watts's "Dictionary of Chemistry," Vol. II., p. 673). The following are experiments of mine made with this substance:—I fused 130 grains of the pure salt in a platinum crucible within a partially covered clay muffle inserted in the hole in the top of a small gas furnace, and electrolysed it during two and a half hours, by means of a current from six Smee's cells, and two flat helices of platinum wire as electrodes. There was free conduction and much gas (of an odour like that of hydrofluoric acid) evolved from the anode, but none from the cathode, and no signs of any deposit. The anode was not corroded, nor altered in weight. I also electrolysed some of the same salt in a state of fusion by means of a current from six Grove's cells, with a thick platinum wire as the anode and the platinum vessel as the cathode. Great heat was evolved, and violent electrolytic action occurred; nearly white hot metallic globules also accumulated and exploded repeatedly. The end of the anode fused, and particles of platinum ramified from it in white hot threads, and a short electric arc (about 1-10th of an inch in length) was produced.

I also perfected and used a somewhat elaborate platinum apparatus, by means of which the gas from the anode was prevented from coming in contact with the cathode, and might be collected, the electrodes being enclosed within (but isolated from) two wide platinum tubes. One thousand grains of the perfectly pure salt were electrolysed in this apparatus by means of a current from six Grove cells. The anode, which was a solid rod of platinum, was rapidly corroded, and was thus cut off at the level of the liquid and stopped the current; the corroded surface was very bright, as if fused. Potassium was deposited upon the cathode. Much spongy platinum was diffused in the melted salt, and the apparatus was a little corroded at the surface of the liquid. No gas was evolved at the anode. The deposited potassium did not alloy with the stout rod of platinum used as the cathode. ·55·35 grains of grey metallic platinum were found in the saline mass; a salt of platinum appeared to have been

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formed at the anode, then dissolved or diffused throughout the liquid and decomposed by the heat, and thus the liberated fluorine did not escape at the anode, but was evolved in the mass of the liquid generally, and came into contact with the liberated potassium.

Having ascertained the electrical relations of palladium, gold, platinum, and iridium in the fluoride, palladium being the most positive and iridium the most negative, I repeated the experiments with an anode of iridium and a current from three Grove cells. Copious clouds descended at once from the anode, and made the liquid opaque; there was also a violent action at the anode. The anode became black, and a little gas was evolved from it, accompanied by an acid odour like that of a mixture of sulphurous anhydride and hydrofluoric acid. Potassium was freely liberated at the cathode, and produced occasional explosions. With a current from six cells the anode dissolved rapidly, and soon lost thirty-eight grains. I then put a pure gold anode, and employed two cells. Gas, of a feebly acid odour, was freely evolved at the anode; and with a current from six cells was very copious, and smelt much like sulphurous anhydride. The gold dissolved much less rapidly than the iridium. With a palladium anode and a current from six cells the anode rapidly dissolved, potassium was deposited, and exploded frequently, and an odour like that of hydrofluoric acid was strong, much gas being liberated; 33·3 grains of free metal were found in the saline mass. The platinum cathode was not corroded.

In the experiments the platinum anode dissolved, as if melted; the iridium one was black, the palladium one was oxidised of various colours. The platinum vessel was cut into at the level of the surface of the liquid, evidently not by the fused fluoride of potassium, but by some substance set free at the anode by electrolysis. In another instance I electrolysed the pure fused fluoride with a large platinum anode, small platinum cathode, and a current from three Grove cells during half an hour. Much gas, having an odour of ozone and hydrofluoric acid, was evolved from the anode, and the latter dissolved rapidly and lost 37·5 grains in weight. The gas reddened test paper. The platinum containing vessel was corroded at the line of surface of the liquid, and lost about eleven grains. About fifty-one grains of free metallic platinum in loose powder was found in the saline residue. Each of these experiments shows that a very corrosive substance was liberated at the anode.

I electrolysed the fused salt with a gas carbon anode and a platinum wire flat helix as a cathode with a current from six Smee's cells. Free conduction occurred, and much gas was set free from the anode only. The part of the anode in the liquid was not visibly corroded.

I also electrolysed about 8oz. of pure double fluoride of hydrogen and potassium (KF HF) in a fused state during half an hour, at about 300° F., with a current from 10 Smee's cells, and electrodes of stout sheet platinum. There was copious conduction, and abundance of hydrogen evolved at the cathode, but no gas from the anode, which was rapidly corroded away, with a rough surface, and lost 9·37 grains. The salt became less fusible by loss of hydrofluoric acid, which escaped freely all the time. The saline residue contained a small amount of dissolved platinum salt, and nearly 9 grains of free metallic platinum. In a second experiment, lasting half an hour, the salt was kept only just fused, and a small gold anode was employed. The conduction was free, and much gas was evolved from the cathode, and a film of bright yellow gold spread over the surface of the salt, and connected the electrodes, unless the liquid was continually stirred. The anode rapidly dissolved (more quickly than that of platinum), and the salt of gold at once decomposed, and set free finely-divided gold as a dull, red-brown powder at the anode. No gas appeared at the anode at any time; that from the cathode detonated on applying a light. There was loose red-brown powder of gold, weighing 1·4 grain, upon the cathode, but of adherent gold only ·05 grain. The anode was corroded, and lost 6·80 grains. The saline residue contained no dissolved gold, but 5·85 grains of red-brown powder, containing 5·30 grains of gold.

(TO BE CONTINUED.)

THE INDUCTION OF CURRENTS IN CORES.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 134.)

Comparison of Current Induction in a Core with a Case of Fluid Motion.

In order to obtain a full mental representation of the state of things in a physical problem of one kind, it may often be of some assistance if we can find one of another kind in which the quantities concerned are similarly connected. Thus, in the theory of the torsion of a solid elastic prism, to get a general idea of the warping that takes place when the section of the prism is not circular, and of the amount of its effect on the torsional rigidity, we may be assisted by the comparison with a hydro-kinetic problem, in which the rotation about its axis of a box of the same shape as the prism, filled with incompressible perfect liquid, sets the liquid itself in motion when the section is not circular (Thomson and Tait, II., Art. 706). Suppose now the problem is one in which certain quantities subjected to given laws go through a series of complex changes in passing from one state to another. If we find another physical problem in which other quantities go through the same changes we have an interesting analogy, to say the least, even if the substituted problem be not more easily conceivable than the original. But further, if in the substituted question the quantities concerned are everyday realities, so that their connections are readily grasped, we have not merely an interesting but a useful and valuable comparison. Again, though this is quite a separate matter and may or may not apply, we may possibly get some assistance in forming a physical theory of the unknown phenomena for which has been found a dynamical analogue.

Start the current in a circuit containing a coil with a conducting core by closing connection with a battery. In the transition from the initial state of no current or magnetic force to the final state of steady current in the coil circuit alone and uniform magnetic force in the core, a series of complex changes, generally referred to as current induction, is gone through by the magnetic force and the current, and something more than a superficial examination is needed to obtain a good grasp of the phenomena as a whole. We require, then, an analogous case in which we can readily see the course of events. There are various comparisons which may be made, but the substitutions are not usually sufficiently simple for the purpose. The only one I can find that is so, is the comparison of the magnetic force in the core with the motion of water in a pipe of the same shape. This requires some explanation before the correctness of the comparison can be appreciated.

Magnetic induction is mathematically subject to the law of continuity of an incompressible perfect liquid. This alone is of valuable assistance when we are regarding the nature of distribution of lines of force in a magnetic field. Further, if we ask what it is in the liquid motion that corresponds to the electric currents that accompany the magnetic force, the answer is that a current line is represented by a vortex line, a current tube of infinitesimal section by a vortex tube of infinitesimal section, the fluid within which is, at the moment, rotating with an angular velocity proportional to the strength of current in the current tube, the axis of rotation being that of the tube. As current tubes are closed upon themselves, so are vortex tubes in a moving liquid. Any possible state of magnetic force with its corresponding electric current has its analogue in a similar state of liquid motion, lines of magnetic force being translated into lines of liquid velocity, and lines of electric current to vortex lines.

The Newtonian equation of motion of a fluid particle, meaning thereby an extremely small portion of the fluid, expressing symbolically the definition of a force as the acceleration of momentum it would produce if it lasted for the unit of time, is

$$F=\sigma\frac{Dv}{dt},$$

where σ is the density, F the force acting upon σ, or the force per unit volume, since σ is the mass per unit volume; σv the momentum, and Dv/dt the acceleration of σ's velocity. It is to be remembered that the force produces its full effect in the direc-

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tion of its action, irrespective of what the actual velocity of the mass acted upon may be. F and v are vectors, and so is Dv/dt, which is a vector parallel to F.

The force F is partly due to the stress on the particle arising from the matter around it, and partly to other causes, which we sum up under the name of external force, acting bodily on the fluid, by unknown agency. The force of gravity, for instance, which appears to act upon matter independently of the matter around it, is treated as an external force.

In any fluid at rest, the internal stress is a simple pressure, equal in amount in all directions about a point, but in general varying in amount from one point to another. In the ideal perfect fluid this is also the state of stress when the fluid is changing its shape. The variation of pressure constitutes a force tending to alter the motion of a particle. Calling the pressure p, and disregarding external force, we have $F = -\nabla p$, the vector decrease of pressure, and

$$-\nabla p = \sigma \frac{Dv}{dt}$$

is the equation of motion of a fluid particle.

This insignificant-looking equation contains volumes of meaning, even without abstruse mathematical investigations to open them out. In fact, there is involved by it, and immediately visible when one looks at it through the proper glasses, a most remarkable property, that of the constancy of the circulation, with astonishing consequences.

The pressure p is a scalar—that is, it has a definite value at every point of the fluid, and requires no directional specification. Its variation $-\nabla p$ is, of course, a vector, has a direction as well as a magnitude, being in fact the force acting upon σ. Bearing this in mind, consider the state of the fluid at a fixed moment, and the alteration of velocity made by the force just after. Select a closed chain of particles, and travel once round it. However the pressure may vary along the circuit, it comes back to its original value at the end. In mathematical language the line integral of the force $-\nabla p$ round the closed chain is zero. By the above equation the same property must be true of the quantity on the right side of the equation, that is of the acceleration of momentum. Let σ be constant. Then the line integral of Dv/dt is zero. Now, defining the "circulation" in a closed circuit to be the line integral of the velocity, *i.e.*, $\int \overline{vds}$, where ds is a vector element of the circuit, its variation with the time is due, first, to the variation in the velocity, and, next, to the variation of form of the moving circuit; that is

$$\frac{D}{dt}\int \overline{vds} = \int \overline{\frac{Dv}{dt}ds} + \int \overline{v\frac{Dds}{dt}}.$$

We have already seen that the first integral on the right side vanishes. In the second, $\frac{Dds}{dt}$ is the rate at which the vector ds is changing, or the difference in the velocity at its ends, or $\frac{dv}{ds}(ds)$, making the quantity to be integrated $\overline{v\frac{dv}{ds}}(ds)$, or $\frac{d}{ds}(\frac{1}{2}v^2)(ds)$; which, being the variation along the circuit of a scalar, necessarily vanishes when summed up. Thus the circulation in the circuit does not change at all. The circulation along that circuit of particles, which may be any circuit in the fluid, whatever value it may have at one moment, will always have that value, and what is more always had it. Thus vortex lines move with the fluid, and vortex tubes keep their strengths unaltered, however they may change their shapes. This results from the constancy of the circulation along a closed line of particles embracing a vortex tube. The same reasoning applies when the density is not constant, but is a function of the pressure. Then $\nabla p/\sigma$ has the same property as that above mentioned for ∇p. Also, if the external force per unit mass be, like gravity, reducible to central forces, the same applies to it. From the constancy of the circulation in a perfect fluid we have the indestructibility and uncreatability of vortex motion, possible permanent differentiation of portions of the fluid from the rest, and Sir Wm. Thomson's vortex atoms. Truly there is poetry in science that infinitely transcends the schoolgirl poetry of belauded and belorded poets, which is, however, no doubt quite suitable for such matters as catching blue flies on the window pane, or calling me early, mother, dear.

Although the equations of motion of a perfect fluid were formulated by Euler in 1755-9, and dozens of eminent men had been working at hydro-kinetics later, a whole century elapsed before the property of the constancy of the circulation was discovered. No one had put on the right glasses, or had managed to focus them correctly, until Helmholtz in 1858 discovered the properties of vortex motion in a perfect liquid, followed a few years later by Sir W. Thomson's extension of the same to compressible perfect fluids, by his theorem of constant circulation, from which, in fact, they follow by elementary reasoning. We are here reminded of another doctor, who discovered another kind of circulation; we refer to Dr. Harvey, and the circulation of the blood. But the circulation of the blood is not constant. For the blood is a viscous fluid, requiring the continual application of force to keep up its circulation. That this is so is much to be rejoiced at by all good men; for, were it otherwise, we should live for ever, and no longer have, as at present, the inexpressible satisfaction of looking forward to a time when we shall console ourselves for the troubles of this life by playing on the harp in the next. Everything is for the best.

Now, since every state of incompressible perfect liquid motion represents a system of magnetic force, as the liquid moves and carries its vortices along with it, its motion remains the representative of the magnetic field of a definite system of closed electric currents similarly moved. But obviously this system of currents does *not* correspond to what would happen in a conducting mass if we started with a given arrangement of magnetic force and then left it to itself. For the magnetic system subsides through the frictional generation of heat by the electric currents which accompany it, whilst the constancy of the circulation precludes the motion of the perfect liquid ceasing. We must introduce viscosity, or internal friction; in other words, give the liquid that property which all known fluids possess. That real fluids are viscous is known to the commonest observation. When at rest, equilibrium requires that there should be no tangential stresses; when the parts of a fluid are changing shape there must be, because we can set fluids in motion by purely tangential stress. The typical illustration is that of the circular bowl containing water set rotating about its vertical axis. If there were no tangential stresses the water would remain at rest. In reality the tangential stress at its moving solid boundary pulls the outside layer of water round after the bowl, the outside layer pulls the next inner one, and so on up to the axis, where the water is the longest in getting up its motion. The final state is that the vessel and water rotate as one solid body. On stopping the bowl it drags back or retards the outer layer, then the next inside, and so on to the centre, where the liquid keeps up its motion the longest.

These tangential stresses are defined in amount by the coefficient of viscosity or of sliding friction. Let liquid be moving in horizontal layers in a definite direction, and let the velocity in any layer be proportional to its distance from the lowest layer, so that if x is the height of a layer, $v = ax$ is its velocity, a being constant. Let the motion be from left to right. Any layer is moving faster than the one below it, and slower than the one above it, and there is mutual stress of the frictional character between contiguous layers thus sliding, of amount ma per unit of area in contact, where a is the constant just mentioned—viz., the upward rate of increase of velocity, and m is the coefficient of viscosity.

Now in the equation of motion of a particle we have to take into account, in the expression for F, of any force on σ arising from the sliding friction set up by the distortion it experiences in general as it moves. The result, by the analysis of stresses and strains, is, in the case of an incompressible liquid, to introduce a new force acting on the particle besides that arising from variation of pressure. Not to go into details which are not wanted here, this force is represented by $-m\nabla^2 v$, which makes the equation of motion

$$F - \nabla p - m\nabla^2 v = \sigma \frac{Dv}{dt},$$

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where F is restricted to be the external force only. The constancy of the circulation is gone, fluid motion may be started by tangential stress alone, and, should there be no forces to keep it up, will cease by surface and internal friction, the energy of the motion producing heat. The rate of dissipation for the whole liquid by internal friction is $4m\Sigma$ (ang. vel.)^2 per second.

But the special case to which our electrical problem corresponds is easily worked out. Let there be a long straight pipe of circular section, containing water or other practically incompressible viscous liquid, and let the motion be parallel to the length of the pipe, say from left to right, and be in cylindrical layers, *i.e.*, only varying in velocity from one layer to another. The cylindrical layers may slide over one another, but liquid must not move nearer to or further away from the axis of the pipe. Consider a layer of radius r and thickness dr moving with velocity v at r. The outward rate of increase of velocity being dv/dr (the a above), the whole tangential force on the inner boundary of the layer per unit of length of pipe is

$$2\pi rm\frac{dv}{dr} \text{ from right to left,}$$

and on the outer boundary,

$$\text{the same, } +\frac{d}{dr}\left(2\pi rm\frac{dv}{dr}\right)dr, \text{ from left to right.}$$

The resultant moving force is therefore

$$2\pi m\frac{d}{dr}r\frac{dv}{dr}dr, \text{ from left to right,}$$

which must equal the acceleration of momentum

$$2\pi r dr\sigma\frac{dv}{dt},$$

if there be no other forces. Equating the last two expressions we find

$$\frac{1}{r}\frac{d}{dr}r\frac{dv}{dr}=\frac{\sigma}{m}\frac{dv}{dt} \quad . \quad . \quad . \quad . \quad . \quad . \quad (62)$$

for the equation of motion of the layer of radius r. Comparing this with equation (14), for the magnetic force in the circular core inside a solenoidal coil, we see that they are of the same form. Magnetic force parallel to the axis is replaced by liquid velocity parallel to the axis, specific resistance by coefficient of viscosity, and magnetic permeability by liquid density. (Of course there is also the silly 4π in the electrical case, arising from the faulty definition of the strength of a pole.)

There may besides be, in the liquid, force arising from variation of pressure; but we do not require it. Let the ends of the long pipe be joined together, or immersed in the ocean, and let the liquid be set in motion by uniform tangential force applied to its boundary, acting parallel to the length of the pipe, of strength X per unit of surface. The surface equation of the liquid is of the same form as the boundary equation of magnetic force in the core, *i.e.* the equation of E.M.F. in the coil surrounding it. For, if m_1 be the coefficient of sliding friction between the liquid and the solid pipe, the frictional retarding force on the outer layer of liquid is m_1v per unit area, making $X - m_1v$ the actual force from left to right on the outer side of the boundary layer per unit area. On the other side of the layer, of infinitesimal thickness dr, there is the frictional stress acting in the opposite direction, of amount mdv/dr per unit area, so the equation of motion of the layer is

$$(X - m_1v) - m\frac{dv}{dr} = \sigma dr\frac{dv}{dt},$$

the right hand member of which vanishes with dr, thus giving

$$X = m_1v + m\frac{dv}{dr} \quad . \quad . \quad . \quad . \quad . \quad (63)$$

for the boundary equation. Comparing this with equation (20), which we may write (using (6) and (15),

$$\frac{E}{l_1} = \frac{R}{4\pi Nl_1}H + \frac{\rho}{4\pi}\frac{dH}{dr} \quad . \quad . \quad . \quad (20\text{A})$$

where l_1 is the whole length of wire in the coil, we see that the boundary equations are of the same form when the depth of the coil is small compared with its radius, and the core fills the interior space. (A modification can be made in the liquid problem to make the boundary equations agree when the coil is not of small depth.)

Having thus a perfect correspondence of mathematical conditions, we may, in considering the nature of induction in the core, dismiss altogether the complicated and cumbrous imagery of a set of currents acting and reacting upon one another at a distance, which it is only possible to manage in simple cases, and substitute the following method:—Let an E.M.F. act in the coil circuit, variable in any arbitrary manner. The magnetic force set up in the core will, at any moment and at every place, correspond in direction and intensity with the fluid velocity set up in a pipe similar to the core, filled with incompressible viscous liquid, if it be acted upon by superficially applied tangential force, uniform in amount per unit area, acting parallel to the axis, such force to vary in intensity in the same manner as the applied E.M.F. in the former case. Of course the viscosity, surface friction and density of the liquid must be properly chosen to suit the electrical data, as we may see on comparing (62) with (14), and (63) with (20a).

The wave-like propagation of magnetic force into the core from its boundary when an oscillatory E.M.F. acts in the coil circuit, and the rapid decrease of amplitude in going inward, and the insignificance of the magnetic force except near the boundary when the oscillations are rapid, are made perfectly easy to follow by the fluid analogue, wherein, with a similar to and fro tangential force on the liquid boundary, the motion is propagated inward by means of sliding friction.

In the core the current density is $-\frac{1}{4\pi}\frac{dH}{dr}$, and the current lines are circles in planes perpendicular to the axis. In the pipe the angular velocity of instantaneous rotation is $-\frac{1}{2}\frac{dv}{dr}$, and the vortex lines are similar circles. That the fluid moving in straight lines can be rotating will be seen by considering that if we impress upon every part of a small mass of the fluid in which the velocity varies a velocity equal to that of its central portion, but in the reverse direction—that is, do away with its bodily translational velocity—there is left only the relative motion of its parts, and that consists of a shear combined with an equal similar rotation. There is current in the core at any point only when the magnetic force varies in the neighbourhood, and in the liquid there is differential rotation only when there is sliding of layers. The heat of the induced currents corresponds to the frictional heat developed by the sliding, and the coil heat to the heat of friction against the pipe. The case of steady E.M.F. in the coil will be next considered, and graphically illustrated.

(TO BE CONTINUED)

ON MECHANICAL DYNAMOMETERS.

BY GISBERT KAPP.

(CONCLUDED FROM PAGE 81).

A handy form of belt-tension dynamometer for laboratory purposes is that devised and used by Mr. Alexander Trotter, to whom the author is indebted for the following particulars:—A loose-grooved wheel A (Fig. 35) is mounted in fixed bearings, and can be rotated either by a handle or by a belt from a prime mover. The wheel B, which is also grooved, is placed on the axle of the machine to be tested (which in Mr. Trotter's case was a model of a centrifugal pump, but might be a small dynamo or any other machine), and an endless cord is led round these two wheels, and also round two other wheels, D and C, weighted as shown. If A be turned in the sense of the arrow, that is, looking at the front elevation, against the hands of a watch, and the wheel B were not allowed to revolve, the result would be that the weight hanging on wheel C would be drawn up and the weight hanging on D would be lowered. The latter is lighter than the former, and if now A were held and B allowed to revolve, the heavier weight C would descend, drawing the lighter weight D up, and at the same time impart to the wheel B an amount of mechanical work exactly equal to that which previously had to be expended in lowering the light

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and raising the heavy weight. In this way we could alternately expend mechanical energy on A and recover it from B. But this process can also be carried on continuously by allowing B to turn and put work into the machine under test, whilst turning the handle on it with such a speed as will just keep the two weights balancing each other. The mechanical energy which is thus put into wheel B is found by multiplying the difference of tension in the cord on either side with the speed of the cord. The speed is found by counting the number of revolutions of either B or A, and the difference in tension is of course half the difference between the weights on C and D. There is a slight correction to be made for the stiffness of the cord and the friction in the bearings of C and D. This can be found by running the apparatus idle.

One great advantage of this dynamometer is that irregularities of speed, which are almost unavoidable with a hand-driven apparatus, are not transmitted to the machine under test. The two weights which, so to speak, are kept floating, whilst balancing force and resistance, form a kind of reservoir of energy; and by slightly rising and falling in obedience to variations in the speed of the handle prevent these variations from reaching the wheel B. On this point Mr. Trotter says:—"In the experiments I had in hand the pump had to be driven with a uniform known velocity, and with a known expenditure

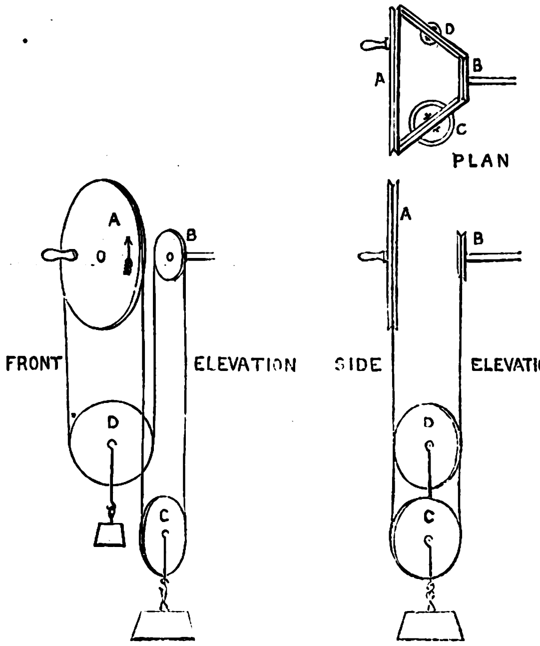

Fig. 35.—Trotter's Belt Tension Dynamometer.

of work. The power was supplied by turning the driving wheel by hand, and was about as much as a man could do. He could watch the movement of the weights, and when the heavier weight rose he slackened, and when it sank he quickened speed, the pump maintaining all the time exactly the same speed."

Hefner-Alteneck's Dynamometer.—This instrument, like that just described, depends on the principle of measuring the difference of tension in the tight and slack portion of the driving belt, but in the manner of taking this measurement there is an important difference. Whilst in Froude's, and also in Trotter's dynamometer, the measurement takes place in a direction parallel to a line joining the centres of the two pulleys, in Alteneck's instrument it takes place in a direction at right angles to that line. For this purpose the belt is deflected on the tight and slack side by being led past idle pulleys mounted in a frame, and the force is measured which must be applied to keep that frame in a position symmetrical to the line joining the centres of the driving and driven pulleys. It will easily be seen that the proportion between this force and the tension in the belt depends on the amount of deflection we may arrange, and that by making the deflection small a considerable tension and therefore a large amount of energy transmitted can be measured by a comparatively small balancing force. This is certainly an advantage, inasmuch as it enables us to keep the size and weight of the instrument within reasonable limits; but it has this drawback, that any error which may creep into the measurements is greatly magnified.*

It will be interesting to compare the first original form of Hefner-Alteneck's dynamometer with its latest development as used in the competitive trials at recent exhibitions. The original form was first brought to public notice in England by Dr. John Hopkinson in a paper read before the Institution of Mechanical Engineers in April, 1879. In Fig. 36 A is the driving and B the driven pulley; C C are idle pulleys deflecting the belt inwards, as shown. If the motion takes place in the direction of the arrow, the lower side of the belt will be

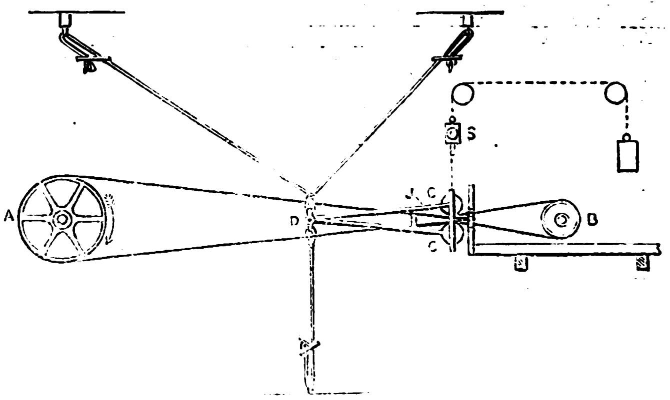

Fig. 36.—Hefner-Alteneck's Dynamometer. Original Arrangement.

tighter than the upper side, and there will be a tendency to displace the idle pulleys, and their supporting frame downwards. To resist this tendency a rope led over snatch blocks and weighted at its end is used. The greater the power transmitted the heavier must be the weight to keep the frame on the centre line A B. It was soon found, however, that the friction of the snatch blocks was objectionable, and a spring balance, S, was therefore inserted in the rope, as shown. The force necessary to keep a pointer on the frame opposite a datum mark was then read off the spring balance. The frame was hinged at the rear on a bar, D, which was provided with eyes, and secured in position by six or eight guy ropes. If we know the dimensions of the pulleys, their distances, and the thickness of the belt, we can calculate the angle of deflection,

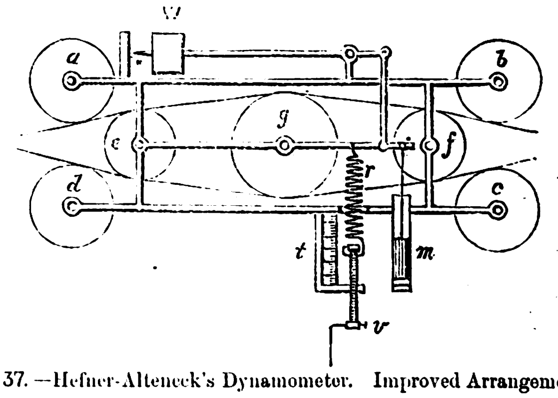

Fig. 37.—Hefner-Alteneck's Dynamometer. Improved Arrangement.

and deduce a formula which gives the difference of tension as a function of these data and the indication of the spring balance. In the hands of a careful experimenter fairly accurate results might be expected even from this primitive arrangement; but the inconvenience of having to rig up the dynamometer for each test anew, and the liability to error where so many measurements have to be taken, are defects which make it unfit for general purposes. In this respect the improved form shown in Fig. 37, and which is also due to

* Compare on this point the official report of the jury on the International Electrical Exhibition at Munich. According to Professor Moriz Schröter these errors became inconveniently large when testing Marcel-Deprez machines for transmission of power.

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Hefner-Alteneck, is by far preferable. It consists of a double frame, carrying the bearings for six pulleys, *a b c d e* and *f*. The frame can be screwed or clamped at any convenient height to a heavy wooden support, which is placed about midway between the prime mover and the machine to be tested. The belt is led through the pulleys, as shown, and embraces a seventh pulley, *g*, which is, however, not carried by the frame itself, but by a lever hinged at *e*. The weight of this pulley and lever is counterbalanced by a weight, *w*, on a second lever, which also serves as index, showing when the pulley *g* is exactly central within the other pulleys. The tendency of a difference of tension in the two sides of the belt is to displace the middle pulley vertically, and to counteract this tendency a spring, *r*, is provided, which, by means of a handle, *v*, can be tightened to any desired amount, and the strain can be read off on the scale *t*. A dash pot, *m*, is added to reduce jerks and vibrations due to belt joints or other inequalities. The instrument is calibrated by suspending it vertically, and attaching known weights to the bottom ends of two separate belts. The difference of these weights is noted, and also the corresponding tension of the spring. During calibration the frame must be constantly tapped with a wooden mallet, to make the joints and levers work freely, but when at work this precaution is not required, since the high speed at which the seven pulleys revolve causes sufficient tremor to prevent any sticking of the levers.

OLD CABLE STORIES RETOLD.—III.

BY F. C. WEBB.

THE UNARMOURED LINE FROM DOVER TO CAPE GRISNEZ.

"Come, get up, Mr. Webb, here's the 'lectric talegraph in the harbour." Thus I was aroused by Captain F. Bullock's old one-eyed steward on board H.M.S. "Widgeon" in Dover Harbour on the morning of August 25, 1850. I hardly knew then what the "'lectric talegraph" meant, and was soon up and prying about on the quays of Dover Harbour till I found a London tug with a great reel of smooth brown-looking stuff across her deck just abaft the funnel. I was only a visitor on board the "Widgeon," but some help being asked from Captain Bullock, Lieutenant Burstal (now Captain Burstal, secretary to the Thames Conservancy Board) was sent with some dozen men on board the "Goliath" (tug) to render any assistance required, and I accompanied them.

The first attempt at a submarine telegraph across the Straits was about to be made. The wire was simply a copper wire insulated with a single covering of gutta percha to a thickness of about half an inch. It was wound on a reel extending across the deck. A cast-iron reel had at first been supplied, but this was so ponderous and heavy that a spar of wood with cast-iron ends was prepared by the late Mr. W. Reid, who was employed by Mr. Wollaston, the engineer in charge on the work. To sink the line and moor it flat leaden weights with a groove running diagonally across them were prepared, so that they could be easily riveted on to the wire. Half the number had two holes in them, and the other half were cast with projecting studs of a size to fit the holes and project a little through. A blow with a hammer on each projecting stud thus riveted them quickly and securely. Some softened gutta percha was placed in the groove to give the wire better protection from the edges of the metal. For shore end the wire was encased in lead.

We went outside the harbour, and the tug anchored close off the works of the Admiralty Pier, then only just begun. There were on board Mr. Wollaston (in charge), Mr. Crampton (a visitor), Mr. H. Brett, the concessionaire, and some other gentlemen. The lead-covered wire was already down the pier, and the end from the tug was joined on to the primitive shore end in a boat. I can well recollect Mr. William Reid (better known by telegraph engineers of that day as "old Reid") standing up in the boat with a soldering iron in his hand, with which he had done something to the lead-covered wire. As soon as we started there was a difficulty in finding a convenient place for riveting the weights together on. I suggested shipping the hawser-bridge. This was done, and a workman sat astraddle across it and had a good place to rivet the lead weights on. At first we stopped altogether to rivet the weights, but after a little while we collected some slack near the taffrail, and then only slowed down and eased the slack over, during which time the weights were being riveted. There was a break on the drum, and at the stern our men from the "Widgeon" had some wet canvas and held this round the wire. Little Mr. Brett came fussing about our men with such impracticable orders that at last they deliberately entangled him in the loose slack, so that he did not come there again. I have no knowledge of the distances the weights were apart, but probably they numbered about 16 or 20 to the mile. I know that a gentleman (I think a Mr. Wollaston, and relative of Mr. Wollaston, the engineer in charge) gave the time to ease down with a whistle. The ship was then eased, a man ran along with a piece of warm gutta percha, clapped it on the lower weight, the wire was pressed into it, another piece put on top, and the top weight put on, two blows given on the projecting studs, and the weight was handed along as the wire slowly paid out again. On the taffrail was a little wooden roller, but no guide of any kind to keep the line on it.

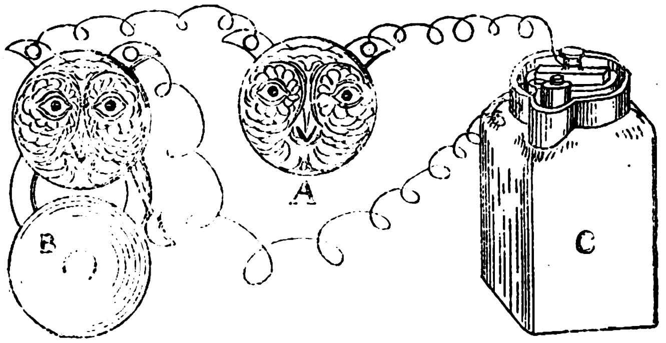
When we got off Cape Grisnez we anchored, and a type printing instrument was put in circuit in the cabin. The instrument began to print off a jumble of letters, and Mr. Brett tore the slip up, although it was a record of the first signals across the Straits. This so incensed Mr. Wollaston that I thought he was going to box Mr. Brett's ears. Being of an archæological turn of mind, I saved a piece and carefully pasted it on paper and labelled it. Captain Bullock requested it of me, and I of course gave it him, and he presented it to the old Duke of Wellington, then staying at Walmer Castle. We joined our own ship, the "Widgeon," soon after this, and did not see the landing of the Grisnez end.

This was my first connection in any way with telegraphy. Of those that were on board Mr. Wollaston, Mr. Crampton, Captain Burstal, Mr. Willoughby Smith, and myself are alive. Mr. Brett died some years ago.

The line was laid to save the concession, which required that telegraphic communication across the Straits should be made before a certain date. The wire answered this purpose, but was cut the day after it was laid by a fisherman, who hooked it up off Cape Grisnez and cut it through with a knife. Dr. Russell, in his work on the Atlantic cable, in alluding to the incident, calls this fisherman a "*pescatore ignobile.*"

ELECTRIC ALARM FOR GREENHOUSES.

Messrs. Jenkins and Co., of Rotherham, are introducing an electric apparatus designed to give warning when the tempera-



Jenkins' Electric Alarm for Greenhouses.

ture of greenhouses and similar places varies from the normal. The apparatus is simple. The case A contains mercury or metal, which expanding or contracting at certain points closes an electric circuit, causing a bell, B, placed in the gardener's house, to ring. The Leclanché cell, C, or cells can be put at any convenient point in the circuit.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

LETTERS.

H. A.—*A letter awaits you.*

CONTENTS.

Notes ... 193
Electro-Chemistry. By Dr. G. Gore. (Continued) ... 198
The Induction of Currents in Cores. By Oliver Heaviside. (Continued) ... 199
On Mechanical Dynamometers. By Gisbert Kapp. Illustrated. (Continued.) ... 201
Old Cable Stories Retold.—III. By F. C. Webb ... 203
Electrical Alarm for Greenhouses. Illustrated ... 203
The City Guilds ... 204
Correspondence ... 205 and 206
The Health Exhibition ... 206
Incandescent Lighting. By T. H. Seymour Hawker. Illustrated ... 207
Conversazione at King's College ... 208
Electrical Testing Apparatus. Illustrated ... 209
Artificial Lighting ... 210
Experiments on the Passage of Electricity through Gases ... 212
Legal ... 214
Companies' Meetings—
Eastern Telegraph Company 215
Faure Electric Accumulator Company ... 216
Companies' Share List ... 216

THE CITY GUILDS.

The report of the Commission on the City Companies has just been published, and proves to be a document sufficiently thorough, we should imagine, to satisfy even the reforming zeal of those who set the Commission to work. Our own interest in the report, however, is attracted mainly by its incidental mention of the circumstance that the Central Technical Institute, the outcome of the Finsbury Technical Schools, together with University and King's Colleges, have in the course of the inquiry submitted claims to the funds of the City Companies whenever those ancient institutions are disestablished and disendowed. At first sight the applications seem not only premature and unseemly, but in the case of the first named claimant very ungrateful, considering the handsome manner in which it has been treated by the doomed Companies during the very short period it has been in existence. The movement on behalf of technical education has been kept going by the zeal and enlightenment of the City Companies, and but for their liberality active work could never have been begun, or, if begun, would have had to content itself with a very modest career for many years to come. As it is, the endowments of the technical schools are all that could be desired, and there is already a vast sum contributed to the great Central Institute at Kensington, chiefly through the instrumentality of the City Guilds.

A little surprise may be pardoned, therefore, when we see the recipients of such favour now foremost among the vultures who surround the dying carcase of their benefactor. But, on reflection, we come to the conclusion that probably they were put on the scent by the Commissioners, who, to justify their killing the game, would naturally be anxious to show that they could easily dispose of it. In this the Commissioners displayed the true instincts of sport, which but for its trophy, or its bag, would give no satisfaction to anybody. The gentlemen who were set on to hunt down the City Companies have shown a very laudable activity in finding customers for their hares, even before catching them, and the Central Technical Institute is by no means behindhand in offering its services as cook.

It is not our province to offer any opinion upon the political aspects of this scheme of confiscation, except perhaps to gently hint that the turn of the spoilers may some day come to be spoiled. If trade corporations are to be dispossessed of their surplus revenues, why not scientific corporations? They have only to grow rich enough to give good dinners, and the parliamentary axe will then be sharpened for their roots. But that, perhaps, is a remote contingency; not so remote, however, as to afford immunity from verbal criticism of a menacing kind. It is a notable fact, and one that comes handy to illustrate our meaning, that only a few days before the publication of this report an evening contemporary of sound Conservative views fell foul of the Central Technical College itself, on the ground that the whole scheme was a job after the manner of South Kensington, and was framed only to put money into the pockets of certain scientific professors whom it named. We are far from endorsing these reckless and no doubt wholly unfounded statements, but they serve to warn us that in these days science is surrounded with no sacred barriers any more than is trade, and when science gets endowments she must look carefully to her expenditure, or the birds of prey will be upon her.

What we are most anxious about, however, are the uses the surplus revenues of these civic institutions will be put to when distributed. There was certainly one complaint made by the newspaper just referred to with which we cannot help in some degree sympathising. South Kensington is not a neighbourhood where artificers or handicraft flourishes, or is ever likely to flourish, and our contemporary protests with some justice against the seeking of a sumptuous habitation for technical teachers when the object ought to be the finding of needy scholars. This is not a very promising beginning even in its days of comparative poverty. What will its condition be when enriched by the redundant capital of the extinct City Guilds? "Easy come, easy go" is a homely proverb applicable as well to modern institutions as to ancient, and its moral is not without meaning for the younger of those fabrics which are rising on the ruins of the older.

We have before now expressed our regret that some method could not have been found for reviving the original objects and functions of these historic corporations. They originally obtained their privileges as overseers of the trades of London. It is idle to lament their having lost their useful powers in that direction; the times have changed, and we cannot reverse their

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order even if we would. But there was still, it seems to us, an opening for good work in the regulation and encouragement of skilled handicraft, which none could have undertaken better than the City Trades Guilds. Especially was this the case in respect to the resuscitation of apprenticeship, without which we gravely suspect all technical school teaching will go for very little in improving the great mass of our working artisans. Science might then have gone to the Guilds with greater advantage; the Guilds have instead gone to science, with consequences which we sincerely hope may be satisfactory, but which we cannot altogether look forward to without misgivings.

CORRESPONDENCE.

PRIMARY BATTERIES FOR HOUSE-TO-HOUSE LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR:—In *The Electrician* of July 5th you have published that portion of Mr. Probert's interesting paper on "Primary Batteries for Electric Lighting" which deals with the vital question of the cost at which an electric current can be produced when using a battery as compared with a dynamo electric machine. May I be allowed to demur somewhat to the details of his calculation?

By way of practical illustration, Mr. Probert supposes the case of a house which has to be lighted with 100 incandescent lamps, and, if supplied from a dynamo, requires a steam engine which must develop 12·55 horse-power. He assumes the prime cost of the installation to be £300, the annual interest on which at 4 per cent. is £12, depreciation (10 per cent.) £30, and cost of attendance about £60, so that the total annual cost works out at £147, or £1 9s. 6d. per lamp.

Now, £300 for the prime cost of such an installation is much too low a price. In his book on "The Electric Light in Our Homes" Mr. Hammond states (p. 157) that an installation of the size of his own, where the average number of lamps used is only 66, costs £650, and even this outlay on plant would bring Mr. Probert's figures up to £196, or to within a fraction of £2 per lamp per annum. To obtain an equal amount of light from gas at 3s. per 1,000 cubic feet (burnt in Argand lamps) would cost £180; at 5s. per 1,000 cubic feet it would cost £300.

Proceeding next to a calculation of the cost of producing the current by the oxidation of zinc, Mr. Probert founds his estimate on the theory of the Bunsen battery, using sulphuric acid to "oxidise the zinc" and nitric acid to "depolarise," and he calculates that in order to develop 12·55 electrical horse-power per hour the following minimum expenditure would be incurred:—

	s.	d.
13lb. of zinc at 2½d. per lb.	2	8½
In the zinc cell, 19½lb. of sulphuric acid, at ¾d. per lb.	1	2⅝
In the carbon cell, 8⅝lb. of nitric acid, at 6d. per lb.	4	4
Total per hour	8	3

	£	s.	d.
Thus the cost of materials per annum (1,800 hours) being	£742	10	0
The interest on the prime cost of the battery, at 4 per cent.	5	0	0
And the annual depreciation, at 10 per cent.	12	0	0
The total cost per an. of 100 lamps would be..	£759	10	0

Or at the rate of £7 11s. 8d. per lamp.

Mr. Probert, however, very truly suggests that there are several ways in which this extravagant cost may be reduced, and the possibility of a "cheaper oxidant than sulphuric acid" being used is the point to which I desire specially to address my observations, since that is one of the main distinctions of my battery. He says: "As to the oxidant, or, speaking more generally, the solvent of the positive element of the cell, sulphuric acid has been replaced among other substances by hydrochloric acid, and a battery employing this liquid has been introduced by Mr. Ross."

This is not quite accurately expressed, for I substitute for the sulphuric acid in the zinc cell nothing but water, with so small a quantity of salt dissolved therein that in the estimate of cost it may be neglected, and thus the outlay of 1s. 2⅝d. on sulphuric acid in the zinc cell may disappear altogether from the above estimate.

It is as a substitute for nitric acid in the carbon cell that I introduce the very much cheaper hydrochloric acid, adding thereto a small quantity of my "Eureka," which brings up the cost of the undiluted "depolarising" liquid to about one penny per lb., or ⅙th of the cost of the less powerful nitric acid* of Mr. Probert's estimate; and, having thus reduced the outlay on the liquids which in theory are required in order to produce 12·55 electrical horse-power from 5s. 6⅝d. to 9d., I am able still further to lessen that estimate by adopting Woodhouse and Rawson's "deposited carbon" lamps, because 100 of these lamps (at 333 candles per horse-power) require only six electrical horse-power to produce the light of 2,000 candles.

Theoretically, therefore, Mr. Probert's estimate of 8s. 3d. for the cost per hour of the materials used to produce the current for 100 incandescent lamps of 20 candle-power may with the Ross primary battery be reduced to 1s. 8½d., as follows:—

	s.	d.
Cost of 6·18lb. of zinc for 6 horse-power, at 2½d. per lb.	1	4
Sulphuric acid in zinc cell	0	0
Liquid used in the carbon cell for 6 horse-power	0	4½
Total per hour for 100 lamps	1	8½

And again:

	£	s.	d.
Cost of materials for 1,800 hours, at 1s. 8½d. per hour	£153	15	0
For interest and depreciation, instead of Mr. Probert's £17, I will allow as much as	70	0	0
Total cost per annum of 100 incandescent lamps...	£223	15	0

Or, at the rate of £2 4s. 9d. per lamp per annum.

This is at the rate of 537 pence per lamp for 1,800 hours, but in practice the cost to the user of a battery will no doubt be rather more. Taking it roughly at ½d. per hour per 20 candle lamp, raises the *theoretical* estimate of "cost of materials" for 100 lamps from the before-mentioned 1s. 8d½d. per hour to 3s. 4⅔d. in *practice;* or from £153 15s. to £305 per annum, thus leaving also a margin of profit between the manufacturers' prices and the cost to the consumer.

Should incandescent lamps in the course of time be so improved as to have their efficiency increased to 1,000 candles per horse-power, as is considered "probable" by Dr. J. Hopkinson, it would reduce the cost of the electric light with primary batteries to one-third of this estimate.

Will you permit me, Sir, to add that primary batteries as now constructed are so much less troublesome and less noisy than dynamos; they are so steady and regular in their action, and may be so easily controlled and kept in order by domestic servants, that I have little doubt of their soon coming into general use for house-to-house lighting. The old-fashioned fallacy as to the excessive cost of zinc in producing electric light cannot be adhered to much longer, and it was generally recognised on the occasion of the brilliant *conversazione* given last week at King's College by the President of the Society of Telegraph Engineers and Electricians, when the rooms were lighted by primary batteries of the Holmes and of the Ross types, which stood in the corners in view of all the visitors, to show that they need not occasion any unpleasant smell in a house. The steadiness of the light was in marked superiority to that of the lamps in the hall, which were supplied from a dynamo.

* The chemical combination (combustion) of 1 gramme of zinc with oxygen evolves only 1,306 gramme units of heat, whereas its combination with chlorine evolves 1,547 units.

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Houses in Mayfair, Belgravia, and South Kensington, &c., ought all to be lighted by primary batteries.

Apologising for the length to which this letter has extended, I remain, Sir, yours, &c., O. C. D. Ross.

21, Austin Friars, E.C.

LIGHTNING CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I have noticed, and read with interest, the articles on lightning conductors that have appeared from time to time in your issues. I beg to draw your attention to the enclosed correspondence, but, before doing so, give you the following particulars :—In the suburbs of this city there is a large brick works; they have on their land two chimney-shafts of about 160ft. in height. They are now erecting a third, and of similar dimensions. All being in a very exposed position, no other tall building or shaft being within a distance of 300 to 400 yards, I wrote as follows :—

"24th June, 1884.

"Messrs. The Stanley Brick and Land Company, Stanley,

"Dear Sirs: On hearing from you I shall be pleased to give you an estimate for erecting a lightning conductor on your new chimney, now building. I need hardly inform you that in an exposed position it is of the utmost importance to have the buildings thoroughly protected.—Yours truly,

"Wilfrid H. Fleming."

"3rd July, 1884.

"The Manager, Stanley Brick Company, Stanley.

"Dear Sir: I wrote you on the 24th ult. respecting lightning conductors for your new shaft, and if not already decided upon shall be pleased to give you an estimate for fixing the same. I called at the office in Crosshall-street, but have been referred back to you.—Yours, &c.

"Wilfrid H. Fleming."

Their reply I enclose, and should be glad to have your opinion on the same. There seems to be no plausible excuse, as the cost is trifling.—Yours, &c.,

Wilfrid H. Fleming.

(Reply.)

"Liverpool, 3rd July, 1884.

"Mr. W. H. Fleming.

"Dear Sir: In reply to your note of to-day's date, the directors have decided not to fit a lightning conductor to our new shaft.—Yours truly,

"Wm. Wethered, pro. Company."

THE CURRENT-CARRYING CAPACITY OF WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Dr. Fleming opens a subject which is most important to all electric light engineers, many of whom, like "Student," look with suspicion on an untried formula. There is one point in your correspondent's letter which does not appear to agree with previous experiments, namely, "that the heat removed from a naked wire is greater by convection than by radiation." It appears to me that in these experiments the amount must be about the same if the temperature does not exceed 50 degrees C. Referring to a paper entitled "Warming Buildings by Steam," which was read at the Institution of Civil Engineers in 1882, the question of radiation is fully gone into as regards the emission of heat from iron pipes. In the discussion which followed Mr. T. H. Blakesley stated that, in accordance with the researches of Dulong and Petit, it appeared that at a low temperature the proportion of heat given out by radiation was greater than that given out by convection, but at about 73 degrees difference (which is, approximately, that between the air and the wires in Dr. Fleming's experiments) the proportion was the same.

As regards the relative heating of the various coils, were they of sufficient length so that the cooling effect of the terminals would be inappreciable? If not, it would, perhaps, account for one metal parting with the heat more rapidly than another, according to its relative conductivity. I pointed out the great influence the cooling effect of terminals has on the melting point of short wires or foils in a previous letter to *The Electrician*. Recent experiments have confirmed this.—Yours, &c. Killingworth Hedges.

Queen Anne's-gate, Westminster, S.W.

ELECTRIC LIGHTING IN MILLS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In the second paragraph of my letter in last week's issue, as to electric lighting, at the end of the paragraph I find I use the expression "considerations of economy and *efficiency*," while I should have said "considerations of economy and *simplicity*."—Yours, &c.,

W. C. Martin.

Commercial-street, Dundee, 3rd July, 1884.

THE HEALTH EXHIBITION.

The following observations are not written for the benefit of those who are familiar with the technicalities of electric lighting, but for those who are interested in knowing something about a subject which is perhaps too often treated in these columns from a scientific point of view. Explain to us as to little children is the request of many sensible people, and we hasten to make the attempt. Unfortunately the subject is one that cannot be fully understood till some knowledge is obtained of it as a whole. It is not necessary to think of the source and the mouth of a river when one stands on its banks at a narrow portion in order to find out why the water rushes onwards with great velocity, raising clouds of foam and spray. We see the water, and perhaps if we could see that which is called the electric current the phenomenon of the electric light would be easier to understand. The rushing water in the narrow river bed is somewhat analogous to the rushing electricity at the point of light. The one causes spray and foam, the other heat and light. In order, however, to have the narrow river bed we must have the river; we must have a source of water—a channel for the water to flow—the action of gravitation causing the water to flow. For the sake of simplicity and on purpose to take advantage in our explanations of analogies that may aid the understanding, we shall speak of a current of electricity just the same as we speak of a stream of water.

In the first instance, let us try and take a rapid glance at the complete system. Imagine a large reservoir of water, and that by means of a steam engine acting on a pump part of the water is raised some distance above the level of the other water and poured into the mouth of a pipe, the other end of the pipe being at the bottom of the reservoir. We all know the water would run down the pipe, and if the pipe happened to have a smaller section at one part than anywhere else the rush through that part would be quicker. Now, with the electric light we have the steam engine driving a dynamo machine which answers to the pump, raising not water but electricity to a higher level, or, as the electricians call it, potential, and putting it into one end of a wire. Like the water through the pipe, we may imagine the electricity going through the wire. In this wire is joined up a piece of something, through which, so to speak, the electricity has to rush faster—like the water through the narrow river bed or the smaller pipe, and in thus rushing faster the electricity causes the material to become very hot; so hot, indeed, that it is rendered incandescent or light giving. A little more may be said of our rushing water. It may be wanted to turn a mill-wheel, and then come questions as to what kind of a wheel, and whether alterations should be made to the channel. In fact when we want the moving water to do work we want as much as possible of it, and so with our electricity. When we ask it to give light or to turn a wheel we want the work done at as small a cost as

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possible. We want all the electric current to do work and not merely a part of it. If we ask for light we want it economically. Again, it must be pleasant, steady, soft, agreeable. It must be amenable to reason; that is, it must be turned on or off, up or down, without danger, at pleasure. Here, then, is the problem our friends the electricians are asked to solve. Give us in our homes a suitable substitute for gas, which is dangerous, dirty, unhealthy, flickering, and in other ways a disagreeable light. It has its advantages, and whatever you give us we must retain those advantages. Have the electricians solved the problem—can they supersede gas, can they give us an improved light at a fair cost without bringing with it a number of disadvantages which render it practically useless? Visitors to the Health Exhibition can judge for themselves in some measure what the electricians can do, for we can assure them that never in the history of electric lighting has a better opportunity been given for a study of part of the subject. The one part of the question that cannot be studied here is the cost.

It can easily be shown that all parts of the apparatus used must be carefully designed if the result is to be satisfactory. Consider again for a short time the reservoir of water, the engine, pump, and pipe. If we require the same quantity of water to flow through a given portion of the pipe second by second, minute by minute, and hour by hour, it will not do to have your engine now running fast, now slow—it must run with absolute regularity. Nor will it do to allow the pump valves to be in a defective state, sometimes acting well, sometimes badly. The water raised by the pump must not vary second by second, nor must the height to which it is raised, and so on. Remember, we are asking the electric light engineer for a more perfect light, and he must see that his engine, dynamo, lamp, &c., are suitably constructed. The velocity of the water under constant head running through the narrow part of the pipe would vary if the section of the pipe varied; it would also vary if the section remained constant while the head of water varied. Let us take, first, that the section of the pipe is never to vary. What answers to this in electrical matters is called by electricians resistance. So we can see that the electricians must, in order to give the light we want, get hold of some material through which the electricity is to pass that will not alter its resistance. Perfection is perhaps impossible, but the electricians have tried to get as near perfection as possible in two ways. In what they call "arc" lamps they endeavour to keep resistance pretty constant by regulating the distance between two carbon points, through which points the electric current is made to pass. We know that a rapid stream of water rushing along between banks of soft earth tears away the material of which the banks are composed, connecting the banks by a bridge of muddy water; so the electric current rushing along tears off particles of carbon from one point, carries them along, and forms as it were a bridge of torn off particles with the other carbon point. If the carbon is perfectly homogeneous the particles will be torn off pretty equally all round, till the carbon at this extremity assumes the shape of a well sharpened lead pencil. Such a carbon will of course enable the user to get a steadier light than another carbon which is non-homogeneous, and which is torn away more in one part than in another. The opposite carbon under the action of the current should assume a cup-like shape. Now, if it was possible to obtain a perfectly symmetrical cone, and a perfectly symmetrical cup, with the apex and sides of the cone always at the same distance from the bottom and sides of the cup, and with a never-varying bridge of carbon particles between, we might get no variation of resistance so far as this part of the lamp is concerned. Sometimes the carbons are not placed end on with an air space between, but, as in the Jablochkoff and other "candles," are placed parallel, or nearly so, and separated by a layer of plaster of Paris, or similar material. The other plan adopted is to make the current pass through fine filaments of continuous carbon, platinum, iridium or platinum-iridium. Carbon filaments are, however, almost the only ones now used.

Here the electrician meets another difficulty. He can get a beautiful light by using this carbon filament; but under ordinary conditions the carbon filament burns away like a piece of coke in the grate. In order to burn the coke we have to raise its temperature by the use of shavings, wood, or something of the kind. When above a certain temperature the carbon or coke combines with the oxygen of the air, forming a new substance which chemists call carbon dioxide. The same would occur with the carbon filament, so the electricians put it into a little globe from which the air has been withdrawn; in other words, they put the filament into as good a vacuum as they can obtain. There are other evils to be encountered; but we will assume for the moment that we have obtained a fairly good "arc" or "incandescent" lamp. Plenty of both kinds of lamps will be found in the exhibition. The arc lamps are very brilliant, and are used to illumine large spaces. The "incandescent" lamps are more like gas jets, and are used for interior lighting.

Now let us consider for a moment the work of the engineer who designs and builds the engines. His friend and colleague the electrician says, No matter the load on your engines, my dynamos must run with exactly the same number of revolutions per minute, hour in and hour out. My dynamo takes the place of the pump, and the head of electricity must be as constant as the head of water. No matter to you whether the pump is constructed to throw a pint or a gallon at each stroke, or to vary the quantity thrown exactly as the quantity used, the number of strokes of the pump must be constant. The engineer listens to all this, and gets somewhat mixed as to his notions about pumps, dynamos, electricity, and water; but he has one fixed idea—that the number of revolutions of his fly-wheel must remain constant under a varying load.

(TO BE CONTINUED.)

INCANDESCENT LIGHTING.

BY T. H. SEYMOUR HAWKER.

(CONTINUED FROM PAGE 153.)

In any of the modifications of the parallel circuit which circumstances may suggest or practical exigencies render advisable, the resistance of the conductor is the ruling consideration. With a sufficient size of conductor, circuits may be run with fairly good results on any or—as many of the present installations justify us in saying—no particular plan. It is when economy becomes a consideration that *system* and a due recognition of the relative or special advantages which fit the typical methods for particular work become important, enabling a less weight of copper to be employed to produce a good effect.

In the earlier stages of electric lighting (and even in some instances in the present) by far the most common defect was the use of wires of too small section, giving the circuit an uniformly higher resistance, and reducing the efficiency of the circuit.

To get a given effect at the lamps in this case would naturally throw a greater load on engine and dynamo than with a good circuit, and when working with a small margin this has been to blame for many of the failures which have from time to time gladdend the hearts of gas shareholders. Experience is, however, credited with the ability to instruct those who do not possess the mental powers to enable them to guide their conduct by reason, and hence we find that many of this class, having probably had the lesson impressed by a salutary rap on the knuckles, have flown to the other extreme, and waste their copper by blindly pinning their faith to a standard of so many amperes per square millimetre of sectional area. The philosophy of such a scale is more than doubtful, even were it possible to grade the conductor so as to retain the ratio of current to section constant at all parts of the circuit, or even practicable to approximate to this by the use of many different sizes. As, however, we shall see when considering the proportioning of conductors in an example circuit, the conductivity is of greater importance at some points than at others, and in fact different limiting conditions affect the size of cable at different parts.

For these reasons any fixed standard will allow too much copper at some places and insufficient at others.

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A standard, moreover, seems to tacitly countenance work more by rule of thumb than by scientific investigation and proper special calculation of quantities for each different case.

The general fault introduced by this system is in the right direction, however, and affects the pocket of the installer and not the efficiency of the light.

With the underwired, haphazard circuit this is different, and means have to be taken to remedy the deficiency of copper or its uneconomical distribution.

This can be done by using lamps of higher E.M.F., and increasing the E.M.F. at the terminals, or by reinforcing the existent wires with others of suitable relative section, which can be looped on branch by branch, as shown in Fig. 5, where the added cables are shown dotted, and the existent high resistant circuit in full lines.

The rule to follow in this correction is to add wires of such section as to give when in parallel with the existent leads a

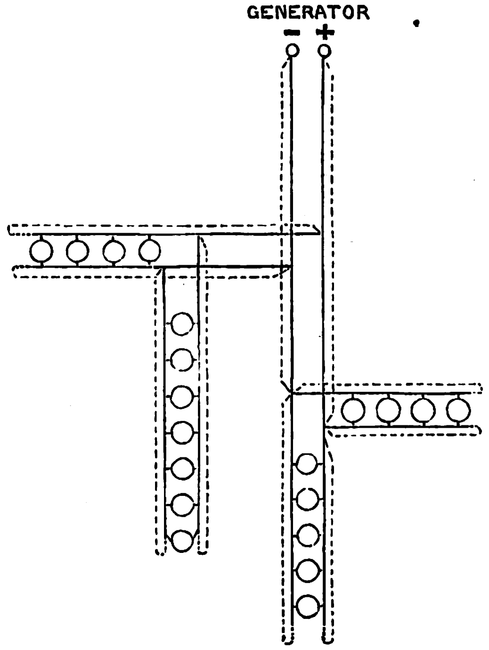

FIG. 5.

conductivity equal to that conductivity required in that portion of the circuit. Thus, if $\frac{1}{R}$ be the required conductivity, and $\frac{1}{r}$ the existing conductivity—in each case the reciprocal of the respective resistances—then the conductivity of the conductor, which must be added in parallel to $\frac{1}{r}$, must be equal to $\frac{1}{r_1} = \frac{1}{R} - \frac{1}{r}$.

The most suitable dimensions for an electric light conductor are determined, generally speaking, by a combination of several ruling conditions, and foremost among those is the increase of temperature which can be safely permitted. While an economical ratio is maintained between the aggregate resistance of the lamps and the resistance of the entire circuit there need be no fear of dangerous heating in any part, but where the section of conductor is otherwise unimportant, as in leads to individual high resistance lamps, the ultimate temperature becomes an important consideration, as it practically limits the economy which may be possible by reducing the weight of copper. Let f = the percentage of heat radiation per unit difference of temperature between a conductor and the surrounding medium expressed as a fraction of entire heat H, contained by the body of mass m, *per unit length*, and specific heat h, at temperature t. Then $H = t\ m\ h$, and the ultimate temperature of the body, if a conductor of resistance R, and surface a, traversed by a current C, will be approximately:—

$$T = \frac{C^2R}{42 \times 10^6 \times m h f a} \text{ (all in C. G. S.).}$$

The constant f is usually taken as = ·00025, but varies considerably with different materials and coverings of various thermal conductivities. The fact that the heat evolved is proportional to the *square* of the current is very important to realise, as it shows that a very small percentage increase of current must have a big effect on the temperature of the conductor. An increase of 41 per cent. will double and 100 per cent. quadruple the heat evolution. If, therefore, we take the safe working current of a cylindrical copper conductor as one half the limiting current, its requisite mass per unit length will be given by the following formula derived from the preceding:—

$$m = C^2R/42 \times 10^6\, h f a t,$$

where t is the limiting temperature in C° of difference from that of the surrounding air or other medium.

This is simple enough to apply in practice if we get the necessary data from any reliable physical treatise; but, unfortunately—at least for the simplicity—the current in a lighting circuit is a most complex function of the E.M.F. at its terminals, and it will be well to consider this matter in detail before proceeding with the methods of determining the sizes of those mains and leads whose resistances are for a given circuit efficiency necessarily too small to allow their heating to be considered. The chief cause of this complication is the variation which occurs in the resistance of both lamps and conductors when a current is passed through them. The variation is in both cases due to, and varies directly as, the heat generated by the flow, which is as we have seen in proportion to the square of current. In the lamp filaments, however, we have the anomalous physical attributes of carbon to contend with, and instead of the almost universal rule of heat *increasing* resistance we find it greatly reduced thereby.

The economical working temperature of a lamp is usually attained when the resistance is reduced to about one half the resistance when cold; but this depends greatly on the "individuality" of the type of lamp used. The luminosity of a lamp is a measure of the temperature of its filament, and is therefore intimately connected with the resistance, and is a very definite function of the cube of the energy evolved therein. We can therefore, by putting L as a measure of absolute luminosity, and Ψ as the ratio of this to the energy cube—C^2R—write:—

$$R_1 = \sqrt[3]{\frac{L}{C^6 \Psi}}$$

In the absence, however, of any absolute system of photometry, this has merely a theoretrical interest, as in practice the lamp resistance R_1 has to be measured directly.

This is best done by a measurement of the E.M.F. at the terminals, when carrying a given current, and a tabulation of a series of such results, with different currents, should be in the possession of every electrician, being invaluable in the calculation of circuit data.

Not only each type, but each size of lamp has a different constant, so a recommendation to experiment on those most in use can alone be given, especially considering the questionable permanency of the lamps at present in the market.

With the conductors the change of resistance is not so great, and can generally be neglected.

In cases of considerable current density, however, the resistance, at a given increase of temperature, becomes important.

CONVERSAZIONE AT KING'S COLLEGE.

At King's College on Thursday week, the 3rd inst., Professor Adams, President of the Society of Telegraph Engineers, gave a *conversazione*, at which many well-known electricians and scientific men were present. Professor Adams received his guests in the entrance hall, the arches of which were illuminated by Edison lamps, of whose performance on this occasion the less said the better. The Wheatstone laboratory was turned into a temporary exhibition of the latest novelties in electrical apparatus. This and the adjoining room were capitally lighted by means of Woodhouse and Rawson 16

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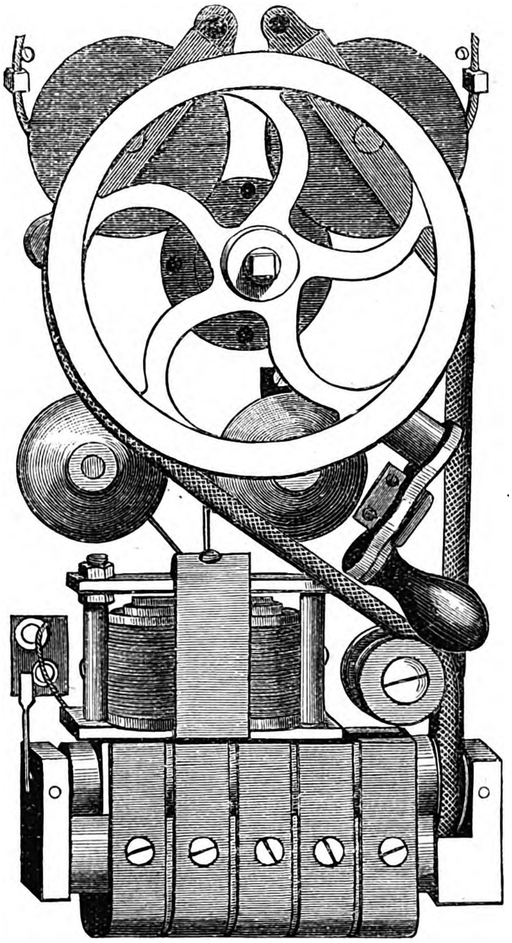
candle-power incandescent lamps, the current being supplied by Ross's primary battery. Mr. Ross was present to describe the construction and working of his battery, of which a model was exhibited, and informed us that many of the zincs in the cells supplying the lamps had been in fairly constant use since March, 1883, and that they were only 3-16in. thick to begin with. The museum adjoining the laboratory was also lighted by Swan incandescent lamps fitted up and lent for the occasion by Messrs. Laing, Wharton, and Down, of Holborn Viaduct, E.C., the current in this case being supplied by 23 of Holmes's cells. The number of lamps employed was 28 of 10 candle-power. The light afforded was pleasant and as steady as could be wished. In the laboratory we noticed a working model of the telpher line, which has given rise to so much discussion of late. Professors Ayrton and Perry exhibited their numerous meters and a foot resistance box, which they have recently brought out for use with their motor. By pressing the box with the foot the resistance of the carbon plates inside is decreased, and on releasing the pressure the resistance is not only increased, but the carbon plates are shaken up by a spring, and the freedom of contact restored, which the mere elasticity of the carbons will not do. The application of this box to motors, and its utility for controlling their working, are obvious. Messrs. Crompton and Co. showed drawings of their electric lighting station at Victoria, specimens of the plates used in Dr. Frankland's accumulators, current and potential indicators, and the Crompton-Crabbe arc lamp. Mr. Gisbert Kapp showed his dynamometer for testing small motors, and an energy indicator. We also noticed a collection of testing apparatus made by Messrs. Elliott Brothers, who also showed a table lamp (incandescent) worked by Skrivanon cells placed inside the base of the lamp, Mr. Hedges' cut-outs, apparatus by Siemens Brothers, Captain Cardew's voltmeter, &c., &c. Mr. A. J. Frost showed a new electrical clock, in which the pendulum is entirely controlled and actuated by electricity. The principal novelty about this is the manner in which contact is made, the circuit being completed for an instant once in every 12 seconds. We may mention that one of these clocks is exhibited at the Health Exhibition, and has been going since October last without a stop. Mr. Latimer Clark exhibited a photograph of Edward Davey, whose name Mr. Fahie so prominently brought before our readers a short time since. It is a recent one, and was brought to this country by Mr. Eaton (Dr. Davey's son-in-law), who was at the *conversazione.* In the upper corridor, outside the laboratory, Mr. J. H. Greenhill showed his new dynamo, which he described in his paper on mill lighting, published in our issue of June 28th; and Messrs. Clark, Muirhead, and Co., exhibited resistance coils and apparatus, showing the effect of retardation on an artificial cable, equal to about 8,000 miles of the Bennett-Mackay cable, at present being laid for the Commercial Cable Company. The effect of retardation, under the circumstances, was very marked, the current taking about three seconds to traverse the entire line to show a signal at the distant end. The total electrostatic capacity of the cable was about 2,400 microfarads, and the total resistance about 1,200 ohms. In addition to this exhibit there were several instruments connected with the making of the Muirhead duplex system, as also Mance's new system of testing apparatus, which has been specially designed for fault testing on cables. The apparatus exhibited was manufactured by Latimer Clark, Muirhead, and Co., of Westminster. The resistance coils and condensers are probably by this time on their way to the Irish and American stations of the Bennett-Mackay cable, where they are to be used for duplexing the cable on Muirhead's system. It was curious to turn from these latest advances in cable working and to study Wheatstone's plans for laying a cable between England and France which he drew out in October, 1840. In the Metallurgical Department Professor Huntington showed the application of electro-metallurgy to the analytical determination of copper. We must not forget to mention the interesting exhibit of Mr. W. H. Preece, consisting of Dvorak's acoustic apparatus and a new photometer, the joint production of himself and Mr. A. P. Trotter. A description of Dvorak's apparatus will be found in our issue of September 15, 1883, together with illustrations. The guests did not separate till a late hour, having, thanks to Professor Adams and his scientific *confrères,* spent a most enjoyable evening.

ELECTRICAL TESTING APPARATUS.

At the *conversazione* of the Society of Telegraph Engineers and Electricians Mr. Killingworth Hedges exhibited a very convenient little apparatus for testing the insulation of an electrical circuit. We give a sketch of the apparatus. It is the invention of Mr. Woodbury, an American gentleman intimately connected with the question of fire insurance.

It consists of a Siemens armature, wound with fine wire, and rotating between the poles of a series of permanent magnets. There is no commutator, and the alternating currents pass through the coils of an electro-magnet, which causes oscillation in a small bar magnet, pivoted at its centre, and carrying a striker placed between two bells.



Killingworth Hedges' Electrical Testing Apparatus.

The gear for putting the armature in motion is, as shown, very compact and simple. Connected in circuit are two steel tapes on rollers, 35ft. in length, and provided with steel clamping jaws at their ends. The driving wheel, as well as the tape reels, are worked by means of the same crank, which, when not in use, reposes snugly in the position shown. The whole is contained in an ebonite case, $8\frac{1}{2}$in. × 4in. × $1\frac{3}{4}$in. in dimensions. The bells will ring through an external resistance of 7,000 ohms when the crank is turned 200 times a minute. The mode of using the instrument is to clip some conductor leading to the earth, such as the stop-cock of a gas jet, with the end of one of the steel tapes, and to attach the others to the electric circuit. When the resistance of the insulation between the system and the earth is less than 7,000 ohms the bells will ring. At less speeds the limit is proportionally less. This instrument requires no skill for its use. Its simplicity recommends it strongly for the purposes of testing, for which it was designed.

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ARTIFICIAL LIGHTING.*

In early times but a small fraction of our forefathers' lives was spent under artificial light. They rose with the sun and lay down to rest shortly after sunset. During the long winter evenings they sat round the fire telling stories and singing songs of love and war; the fire light was sufficient for them, except occasionally during grand feasts and carousals, when their halls were lighted by pine wood torches or blazing cressets. But, as a rule, after sunset they lived in semi-darkness.

From that early period, as man has advanced in civilisation, in the thirst for knowledge derived from books, and in following the gentler pursuits which demand an indoor life, there has been a steady increase in that fraction of our lives which is spent under light other than that of the sun. But the improvement in the quality of the artificial light has been very slow. The ruddy lights and picturesque shadows so faithfully handed on to us by Rembrandt's pictures show us very graphically what our poets have called "the dim glimmer of the taper" of those days. A few years before the introduction of gas Argand, by his improvements in the burners of oil lamps, enabled our fathers to see for the first time a comparatively white light, but as far as the matter we to-day propose to discuss is concerned, viz., the effect of artificial lighting, and more particular electric lighting, on our health, we need only consider the reign of artificial light as it commenced with the general use of gas and petroleum, for then and then only could it be said to affect our health.

Prior to the introduction of the electric light we have been accustomed to consider hours spent under artificial light as hours during which all conditions are less favourable to perfect health than they would be during daylight. Can we now hope to ameliorate this condition of things through the agency of electricity? Before we can discuss this question I must point out to you the chief differences which exist between hours of work or recreation spent in daylight and under artificial light. In the former case we live in abundance of light. The sunlight itself exercises a subtle influence on our bodies; that mixture of heating and chemical rays which when analysed form the solar spectrum, and combined form the pure white light of daylight, is needed to enable all animal and vegetable organisms to flourish in the fullest conditions of healthful life.

In nearly all cases when the sun is up the functions of life are in the state of fullest activity, and when it sets they sink into comparative repose. In daylight life wakes, in darkness life sleeps. In addition to the abundance of pure white light, the heat attending sunlight is only that necessary for health. The air remains unvitiated, except by our own breathing. On the other hand, when working under artificial light, we have these conditions all altered in degree:

1st, we have an insufficient light; as a scale of lighting by gas or by electricity which would be pronounced excessive at night time is still far inferior to average daylight.

2nd. All artificial lights, whether produced by combustion, as in the case of candles, oil, gas, and petroleum, or by the incandescense of a conductor by the means of electricity, produce heat; this heat, in proportion with the light afforded, is enormously in excess of the heat given by sunlight. Electricity, as you will see hereafter, is far the best in this respect, but even it is inferior to sunlight.

3rd. All these same illuminants, excepting electricity, contaminate the air, and load it with carbonic acid, sulphur, and other compounds—all injurious to the health and to the general comfort of the body.

It will be convenient to consider the effects—first, on our health generally; second, on our eyesight in particular. I have already called your attention to the fact that that proportion of coloured rays which when combined form white sunlight is that best suited to healthy life. It is necessary for that sufficient and proper stimulus to the organic changes which go on in our bodies, and which we call a state of good health. The various artificial lights differ very widely from sunlight in this respect, that they are all more or less deficient in the rays at the violet end of the spectrum, commonly called the actinic rays, and which most probably exercise a very powerful effect on the human body. It is the want of a due portion of these violet rays which makes all artificial light so yellow. Even the light of the electric arc, which is richer in these rays than any other, is still on the yellow side of sunlight. The incandescent electric light is next best in this respect; next in order comes gas, petroleum, and the various oil lamps. No doubt some of you will challenge my statement that the electric arc is yellow. It has always been called a cold blue light. It is not so; it is only by comparison with the yellower light of gas or with the incandescent lamps that it appears blue; when compared with the sunlight reflected from a white cloud it will be seen to be distinctly yellow in tinge, but still both classes of electric light are far superior to all others in nearest approaching the white light of daylight, and thus satisfying the actinic action which our bodies demand.

Turning now to the comparative heating and air vitiating properties of artificial lights which we shall find it convenient to take together, I have here a table (Table A) prepared by Dr. Meymott Tidy, which shows the oxygen consumed, the carbonic acid produced, the air vitiated and the heat produced by the combustion of certain bodies burned so as to give the light of twelve standard candles, to which Mr. R. Hammond has added the heat produced by a 12-candle incandescent electric lamp.

Table A showing the oxygen consumed, the carbonic acid produced, and the air vitiated, by the combustion of certain bodies burnt so as to give the light of 12 standard sperm candles, each candle burning at the rate of 120 grains per hour:—

Burnt to give light of 12 candles, equal to 120 grains per hour.	Cubic feet of oxygen consumed	Cubic feet of air consumed	Cubic feet of carbonic acid produced	Cubic feet of air vitiated	Heat produced in lbs. of water raised 10°F.
Cannel Gas.........	3·30	16·50	2·01	217·50	195·0
Common Gas	5·45	17·25	3·21	348·25	278·6
Sperm Oil	4·75	23·75	3·33	356·75	233·5
Benzole	4·46	22·30	3·54	376·30	232·6
Paraffin	6·81	34·05	4·50	484·05	361·9
Camphine	6·65	33·25	4·77	510·25	325·1
Sperm Candles ...	7·57	37·85	5·77	614·85	351·7
Wax	8·41	42·05	5·90	632·25	383·1
Stearic...............	8·82	44·10	6·25	669·10	374 7
Tallow...............	12·00	60·00	8·73	933·00	505·4
Electric Light ...	none	none	none	none	13·8

From these figures you will see that the air of a room lighted by gas is heated twenty times as much as if it were lighted to an equal extent by incandescent electric lamps. When arc lamps are used the comparison is still more in favour of electricity. You will be surprised to see from the table that our old friend the tallow candle, and even the wax candle, is far worse than gas in the proportion of air vitiated and heat produced, and you will be disposed to disbelieve it, but the fact is that so long as candles were used light was so expensive that we were obliged to be content with little of it; in fact, we lived in a state of semi-darkness, and in this way we evaded the trouble. It is only since the general introduction of gas and petroleum that we have found what an evil it is.

It is not unusual, in fact we almost always find the upper stratum of air of the rooms in which we live heated to 120 degrees after the gas has been lighted for a few hours. We have grown accustomed to this state of things, and are not surprised that when we take the library ladder to get a book from the upper shelf we find our head and shoulders plunged in a temperature like that of a furnace, producing giddiness and general malaise. If you look again at the table you will see that each gas burner that we use consumes more oxygen and gives off more carbonic acid, and otherwise unfits more air for breathing, than one human being, and it is this excessive heating and air vitiation combined which are the main causes of the injury to the health from working long hours in artificial light. I could go on for a long time giving instances of the fearful state of the atmosphere of our large public buildings as well as of our private homes after the gas has been lighted for a few hours, but this paper is not intended as an onslaught on gas; moreover these ills are so well known to nearly all of

* Lecture delivered at the Health Exhibition by R. E. B. Crompton, Esq.

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you that I need not bring them more prominently before you. I will only take one instance, viz., that of the Birmingham Town Hall, which has been lighted alternately by gas and electricity.

During the grand Birmingham Musical Festival, which was held in that hall two years ago, some careful experiments were made to show how the orchestra and audience in the hall were affected by the two kinds of lighting. The gas lighting was in the form of several huge pendants suspended down the centre of the hall. The electric lighting was in the form of clusters of lights placed on large brackets projecting from the side walls, with two central pendants spaced between the gas pendants. The candle-power given by the electric light was about 50 per cent. in excess of that given by the gas light, the degree of illumination by electricity was consequently very brilliant.

It was found that when the gas was used the temperature near the ceiling rose from 60 degrees to 100 degrees after three hours' lighting. The heating effect of the gas was, therefore, the same as if 4,230 persons had been added to the full audience and orchestra of 3,100. Similarly the vitiation of the air by carbonic acid was equal to that given off by the breathing of 3,600 additional persons added to the above audience of 3,100. But on evenings when the electric light was used the temperature only rose one-and-a-half degrees during a seven hours' trial, and the air, of course, was only vitiated by the breathing of the audience. The further experiment was tried of giving to every member composing the large orchestra a printed paper of questions asking him how the new mode of lighting affected him or her personally, and I have here 265 replies to those questions. They are very interesting. I will read a very few of them out to you.* From them you learn that without exception the comfort and general well-being of this large orchestra was increased enormously by the use of the new illuminant, and it is reasonable to suppose that the comfort of the audience was increased in an equal degree. I must here add that I have to thank Mr. Henry Lea, of Birmingham, who conducted these experiments, for kindly allowing me the use of his papers. Now, we all of us know that the times when we suffer most from the effect of artificial light is in crowded places of public amusement, which are at the same time brilliantly lighted. Many of us are unable to go to the theatre or to attend evening performances of any kind, as the intense headache which invariably attends or follows our stay in such places entirely prevents them. This headache we commonly say is inseparable from the heat and glare of the gas. Now, this phrase is not strictly correct. It is, no doubt, due to the heat of the gas and its air-vitiating properties, but when we use the word glare I believe we refer to the effect the gas light has upon our heads, and which effect is not due to excess of light. On the contrary, I believe if a far greater amount of light be given by the electric light without the heating and air vitiation being present such headache is never produced, although some of the more tender headed amongst us will at first complain of the glare because they are habituated to associate plenty of light with great heat, great air vitiation, and other evils.

Indeed, so long have we been accustomed to closely associate brilliant artificial light with headache and glare, that we who are introducing electric light are most cautious not to give the full quantity of light which we could afford to give, and which would afford the greatest rest to the eye and greatest bodily comfort. I now come to the effect that light has upon the temperament. If we try the experiment in an assemblage of people of gently decreasing the lighting of the room, it will be found that the spirits of every one will be depressed just as the light is depressed, and, *vice versâ*, their spirits will be raised just as the light is raised. I have many times when conducting experiments of electric lighting on a large scale noticed this fact, and I have been led to the conclusion *that during hours of waking every person is benefited by increase of light up to the extent of full sunlight*, providing that this high degree of lighting is not attended by heat and by air vitiation; and I must add that the source of light must not be from one or two brilliant points only, but it must be well distributed and not such as to cause dark deep shadows.

This leads me on to the subject of the effects on the eyesight of the electric light as compared with other lights. *Healthy eyesight demands a plentiful supply of light. It is the greatest mistake to suppose that a state of semi darkness is good for our eyes*, unless they are defective, or recovering from the effects of past injury or disease. Whoever saw a painter, engraver, printer, watch maker, or indeed anyone the quality of whose work depends on the excellence of his eyesight, who did not desire a flood of pure white light thrown on to his work. I think I have the authority of oculists when I say that 19-20ths of the diseases of the eyes arise from working the eyesight long hours with insufficient light. Again, another great cause of injury to eyesight is the unsteadiness of most artificial lights. Much improvement has been made in the light of gas during the last few years by the introduction of argand burners, and globes for the flat gas burners having much larger lower openings, so that the dancing and flickering batswing burner of five years ago is not now common in a good house. But even the steadiest of the modern gas burners is extremely unsteady as compared with the light of the incandescent electric lamp. Those of you who have been to the Savoy Theatre will have noticed the effects of the lights behind the scenes on the scenery itself. The light is so absolutely steady that it is comparable to sunlight. Hitherto I have said nothing as to the comparative excellence of the two forms of electric light, viz., the electric arc and the incan-

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* *The following are some of the answers to Mr. Crompton's questions to the band and chorus:—*

Well lighted, the atmosphere of the room greatly improved, and the equal temperature of the whole building has greatly diminished the risk of taking cold from the draughts in entrance and exit.

Much more pleasant than on any other occasion, in fact I never saw a more brilliant light in any hall or concert room in my life. It is a great success, I should imagine.

Well lighted, very much cooler, thus allowing *us* to warm to our work by our own exertions, and also to cool down by resting. A general satisfaction is expressed at the improvement of the comforts of the workers.

At a comfortable, even temperature the light has not afflicted me in the least, although I sit in between four dozen, and on a line to the side gallery lights. The gas used to make me dim.

I, as a member of the Festival Choral Society, think your improved light is a source of great pleasure to those of us that have to occupy the orchestra so often during the concert season.

I have never been on the orchestra before this Festival, but I found the part of the orchestra I occupied was as cool as the floor of any previous concert that I have attended in this or the Wolverhampton Hall.

Cooler and fresher, likewise the violin strings of my own instrument have not been subjected to variation in pitch or otherwise, as is often the case with gas, and think this is important on such occasions when a cool atmosphere is an acquisition to a body of instrumentalists.

Lower in temperature, could see music books better. Freedom from oppressiveness—attended six previous Festivals, someone has fainted. I believe this has not happened this time.

Very cool as regards temperature compared with the temperature when gas has been used to light the orchestra. Instruments have been better in tune with organ. Light excellent.

Very much cooler than on former occasions, and free from that nasty gaseous vapour that made breathing difficult, and parched the throat and injured the voice.

Very much cooler than is usually the case with gas. The light is very pleasant, being a cool white light, not trying to the eyes, always keeping the same colour, never jumping as I have found the case with other electric lights.

Exceedingly cool and agreeable. Certainly one of the most pleasing reminiscences of the 1882 Festival will be the advantages of your electric light.

Delightfully cool, and at the close of the performance but very slightly different in temperature than at the beginning. It is vastly superior to the old system of lighting by gas.

Brilliantly and equally lighted; whilst from my elevated position on the uppermost seat by the side of the organ, had the hall been lit by gas the heat would have been simply unbearable.

Deliciously cool and comfortable, no comparison with any preceding Festival, the heat at the end of the evening being scarcely greater than at the beginning. There has not been one case of fainting near me.

Remarkably cool; in fact the change from the shifting atmosphere under ordinary circumstances is wonderful. I sincerely hope that arrangements can be made to secure this lighting as a permanency.

Much more comfortable in consequence of the substitution of the electric light for gas; it has been but very little warmer for the evening performances with the light than for the morning performance. I have sung in all the principal halls in London (including Royal Albert Hall, Kensington,) and have always found the orchestra quite unbearable soon after lighting the gas. I have pleasure in speaking most favourably of your light, and the comforts in every respect attending it.

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descent lamp. Both have their proper places. The arc light, which is the whitest in colour and most economical to produce, is not so steady as the incandescent lamp. It is therefore unsuitable for indoor use or for reading by, or for such occupations as require the maximum of steadiness. But it is well suited for the lighting of large buildings and public places. I am unaware if any experiments have been made as to the effects of brilliant arc lighting on the eyesight of men who have to work night shifts, as although the opinion of the workmen who have to work under it is unanimous in its favour, yet that opinion is more based on their personal convenience, due to their being able to carry on their work with facility almost equal to that given by daylight than with special regard to their health. The large sorting rooms at the General Post Office at Glasgow have been for a long time lighted by the arc light, and with a most beneficial result to the health and eyesight of the letter sorters and telegraph clerks. The former occupation is one which tries the eyesight very severely. The public generally does not know how the habit of writing the addresses on envelopes with pale ink and blotting it off rapidly before it has time to darken tries the eyesight of the Post Office letter sorters. So long as gas is used a powerful burner has to be brought very close to the head of the sorter, and under such conditions the eyesight fails at an early age. At Glasgow Post Office I am able to boast that by the introduction of the electric light I enabled many of the more aged sorters who were commencing to use spectacles to do without them—and even I put back the clock of time, in enabling several who had used them for some years to discontinue them. I am aware that it has been alleged by the opponents of the electric light, whether interested or otherwise, that in many cases the intensity of the light has injured eye sight. I do not think any such cases can be substantiated. Many of us who are in the habit of experimenting with powerful arc lamps have had our eye lids temporarily affected by incautious exposure at too short a distance. Again, over and over I met with the complaint that if I stare at an arc lamp for a long time it will make my eyes ache; the obvious retort being why should you stare at the light? If you do the same with the sun you will be equally inconvenienced. Before such an audience as this, which is, of course, familiar with the beautiful electric lighting in the Health Exhibition itself, it is useless for me to enlarge on the many conditions of the electric light as it indirectly affects health. I may only name the many additional pleasures of the eye we get from its use. Our flowers in our rooms do not fade away, and are seen in their true colours. Our pictures or all coloured objects are seen to better advantage. I may mention one thing which would not generally occur to you, that in London certainly an electric-lighted house can be cleaned properly in winter. You may smile at this, but I assure you that the advantage of being able to turn a flood of light into your drawing rooms and dining rooms at six o'clock on a winter's morning, and this without taking away the freshness of the air, so that the whole of the cleaning can be finished as thoroughly as if done by daylight before the family comes down to breakfast, is one that must be experienced before it can be thoroughly appreciated. Again, the advantage to the health of our children is simply inestimable. No night lights, matches left about, or gas turned down low are required. A child six years old can be trusted to press a button and so turn the light off or on; the lamps being high and out of reach are not easily broken or over-turned, and the air of the children's nursery, even if the light be kept burning the night through, remains pure throughout. Another indirect advantage due to the absence of heat is that it is comparatively easy to thoroughly ventilate and cool during the hot weather a room lighted by the electric light. The heat of gas placed high in the room causes such intense draughts when the windows are open that the discomforts and dangers of the draughts are almost worse than the discomfiture from the heat and vitiated air, whereas in an electric lighted room there is no difficulty in opening wide all the windows, the draughts produced being so gentle as to hardly be felt.

[We are sorry to be unable to find room for the discussion on this paper.—Ed. *E.*]

EXPERIMENTS ON THE PASSAGE OF ELECTRICITY THROUGH GASES.

SKETCH OF A THEORY.*

The passage of electricity through gases has of late years become a very favourite subject for experimental investigation. A large number of facts have thus been accumulated, and it becomes of importance to see whether these facts throw any light on the theoretical notions which we have based on other branches of electrical inquiry.

If we have two bodies at a different electrical potential separated by a layer of air, we might imagine the air in contact with the bodies to become electrified, then move on, impelled by the electric forces, and re-establish equilibrium by giving up their charges. The passage of electricity through gases would then be similar to the diffusion of heat. But, however natural such a view would be, it is impossible to maintain it in the face of experimental facts. The experiments which I shall bring before you to-day seem to me to support, on the contrary, the idea that the passage of electricity through a gas resembles the phenomenon studied by Helmholtz under the name of electrolytic convection.

I shall avoid as much as possible all suppositions and hypotheses, which cannot be put to the test of experiment; but it seems necessary to start with some assumption in order to avoid too great a vagueness in the subsequent explanations. The assumption which I shall make is this: In a gas the passage of electricity from one molecule to another is always accompanied by an interchange of the atoms composing the molecule. I shall also try to prove that many facts are easily explained by the assumption that the molecules are broken up at the negative pole.

If, in a vacuum-tube of the ordinary form, the discharge is passed at a pressure of about one millimetre, a luminosity is seen round the negative pole which is called the negative glow. A luminous tongue projects from the end of the positive pole, which I shall call the positive part of the discharge, without meaning to imply that it is charged with positive electricity. The positive part of the discharge and the negative glow are separated by a non-luminous space, which I shall call "the dark interval." The glow itself is divided into three layers, the thickness of which increases with decreasing density. Closely surrounding the electrode itself, we have in the first place a luminous layer, which on new electrodes is of a golden colour. The spectroscope shows the presence of sodium and hydrogen; the sodium is due to foreign matter deposited on the electrode, and the hydrogen is expelled by the action of the heat out of the electrode by which it had been absorbed. When the electrodes have been in use for some time the golden colour disappears, and the spectrum belonging to the gas used is seen. The second layer is known by the name of the dark space. The third layer is the glow proper.

The theory which I shall endeavour to establish is this: That within the first layer the gaseous molecules are decomposed, that their negative parts are projected with great velocity through the dark space, that this velocity is gradually reduced by impacts within the glow, and that in the positive part of discharge the discharge takes place by diffusion except when stratifications appear.

According to the kinetic theory of gases, the molecule of mercury vapour consists of a single atom, which is incapable of vibration. Mercury has a very brilliant spectrum, which proves that the theory is incomplete in some important point. It is well known, on the other hand, that the theoretical conclusion receives support from the fact that the vapour density of mercury vapour is anomalous. If, as is generally supposed, the molecule of the majority of gases contains two atoms, that of mercury can only contain one. If an essential part of the glow discharge is due to the breaking up of the molecules, we might expect mercury vapour to present other and much simpler phenomena than the gases with which we are

* Abstract of the Bakerian Lecture. Read before the Royal Society, June 19, 1884, by Prof. Schuster, Ph.D., F.R.S.

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generally accustomed to work. *This, indeed, is the case; for I find that, if the mercury vapour is sufficiently free from air, the discharge through it shows no negative glow, no dark spaces, and no stratifications.* At the ordinary temperature the spark does not pass through mercury vapour; but if a tube free of air, but containing mercury vapour, is heated, the discharge passes always in a continuous stream of light. It is not always quite symmetrical with respect to the two poles, and a very curious tendency of the spark is noticed to pass at the negative pole rather from the glass out of which the electrode protrudes than from the metallic electrode itself. A brilliant sodium spectrum then appears at the point from which the spark sets out. Whenever small traces of air remain, stratifications are very apt to appear, as a mixture of air and mercury gives fine stratifications, but I have never noticed them after sufficient removal of the air.

I now pass to the description of an experiment which seems to me to be only capable of explanation by the views brought forward in this paper, and I should like, therefore, to consider them as crucial experiments, which have to be explained by any true theory of the discharge. As negative electrode, I use an aluminium cylinder of 5·5 cm. internal diameter and 8 cm. long. A long aluminium wire running parallel to the axis of the cylinder at a distance of about an inch formed the positive electrode. On exhaustion, the discharge at first passes as a spark in the ordinary way, but as the pressure decreases the glow gradually surrounds the whole cylinder, *with the exception of a dark strip about 2 or 3 cm. in width, directly opposite the positive wire.* The positive electrode seems, therefore, to repel the negative glow.

The following seems to me a plausible explanation of the phenomenon which I have just described. The rapid fall of potential which is observed on crossing the negative electrode suggests at once, independently of any theory that we have to deal with, the action of a condenser, for we know that no statical charge can produce a finite difference of potential at the electrode, while a double layer will produce a discontinuity. Although it may not be proved that an absolute discontinuity of potential exists at the cathode, it is yet certain that a very rapid fall occurs at that place. This is all that is necessary for the argument.

We recognise such a double layer in the case of electrolytes, but there is an essential difference in the thickness of the layer within which we must imagine that condenser action to take place. In the liquids that thickness must be very small, as is shown by the intensity of the observed polarisation currents. The positively electrified matter in every case is kept against the negative surface by a joint action of electrical and chemical forces, for it has been shown by Helmholtz that only thus can we explain a difference of potential between two bodies. It is the chemical forces which keep the electricities asunder. The gaseous molecules or atoms, however subject to their mutual encounters, and always having certain velocities, will tend to leave the surface. They are kept near the surface, however, by the electrical forces.

Suppose, now, that a positive electrode is placed near such a condenser. The resistance of the gas is so much greater than that of the metal electrode that we shall assume the whole electrode to be of the same potential. The lines of force will then cut the surface at right angles, and could we assume the condenser to be infinitely thin, there would only be a normal force acting on its particles; but as the lines of force are curved, the particles not in immediate contact with the surface are acted on by a tangential force which will tend to drive them away from the positive electrode. As a steady state will only be possible when the total force is normal throughout the condenser, we arrive at the condition for the steady state that within the condenser the fall of potential must be the same for equal distances measured along the normal to the surface.

Experimental evidence speaks strongly in favour of such a conclusion. If, for instance, a thin wire is used as electrode, it is well known that the tension at the end of the wire before discharge is very much larger than anywhere else. At high pressures the discharge passes indeed from the end of the wire, but as the exhaustion proceeds, the glow gradually covers the whole wire, and the same amount of electricity flows out of equal areas situated anywhere on the wire, for the dark space which alters its width with the intensity of current is everywhere the same; this implies that the fall of potential per unit distance is the same all over the wire.

Hitherto we have only assumed a certain number of particles positively electrified in the immediate neighbourhood of the negative electrode, and we have left it altogether undecided what these particles are. But if we consider now the fact that the glow does not appear opposite the positive electrode—that is to say, that while the fall of potential is the same all over the surface the flow is stronger at some places than at others, we are driven to the conclusion that the flow does not altogether depend on the fall of potential, and we must again look for an explanation in the chemical as well as the electric forces. Wherever the fall of potential is chiefly produced by the presence of the positively electrified particles, which I now assume to be the decomposed molecules of the gas, these will help by their chemical action to decompose other molecules. Opposite the positive pole the fall of potential is principally due to nearness of that electrode; chemical forces are absent, and the molecules will not be decomposed, This is, I believe, the explanation of the dark area. And it brings with it the explanation of a large quantity of other facts, as, for instance, the one which has been so long observed and well established, that once a current is set up in the gas it requires a much smaller electromotive force to keep it going. For the discharge, according to us, will generally be introduced by a spark which must give the first supply of decomposed molecules before the continuous glow discharge can establish itself.

I may for the sake of clearness once more mention shortly the principal points of the argument.

The rapid fall of potential in the neighbourhood of the negative electrode renders the presence of positively electrified particles in its neighbourhood necessary.

If the distance through which the condenser action takes place is sensible, the positively electrified particles will be acted upon by a neighbouring positive electrode.

A steady state will be established in which the fall of potential along the normal from the surface will be everywhere the same.

As, however, the flow is stronger away from the positive electrode, we must conclude that other forces besides electrical forces determine the flow.

It is natural to assume that these are chemical forces; that, in other words, the positively electrified particles are the decomposed molecules, which by their presence assist the decomposition of others, and therefore the formation of the current.

Unless a flaw is detected in this line of argument, I think that the conclusion must be granted, namely, that the decomposition of the molecules at the negative electrode is essential to the formation of the glow discharge. This is really all that I endeavour to support in this paper. The rest can only be settled by further experiments. And amongst the rest I count also the primary cause which originally produces the decomposition of molecules at one pole rather than at another. It is possibly due to an electromotive force of contact between the gas and the electrodes which tends to make the gas electronegative.

The gaseous molecules, then, according to our theory are decomposed at the negative pole. Their negative constituents can follow the electric action, and as the fall of potential in the immediate neighbourhood of the pole is very rapid, the atoms will leave the pole with considerable velocity. That the region of the dark space is filled with matter projected from the negative pole follows almost conclusively from the experiments of Goldstein and Crookes, and is also shown in a most striking way by an experiment due to Hittorf. If a tube contains two parallel wire electrodes at a distance of say a quarter of an inch, the discharge will at high pressure pass in the usual way from electrode to electrode, but at a very low pressures the discharge from the positive pole goes away from the negative. The results can be shortly expressed by saying that, as far as the positive pole is concerned, the inner boundary of the dark space forms the negative electrode. If the dark space is small

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and does not reach the positive pole, the discharge passes from the latter towards the negative pole, but as soon as the dark space extends beyond the positive pole, the positive part of the discharge goes towards the nearest point of the dark space that is straight away from the negative pole.

We have then two closely adjoining, almost overlapping parts, in which the discharge is in opposite directions, and this could not be unless electricity is carried by matter which can, owing to its inertia and high velocity, move against the electric forces. To my mind this experiment proves conclusively that the negative electricity is bound to matter projected with high velocity away from the negative pole.

Goldstein has shown that when a thin pencil of the negative glow belonging to one electrode passes close to another the pencil is deflected. According to our view, such a pencil would be formed by a succession of negatively charged particles projected in nearly the same direction away from the negative electrode; as these particles pass by another cathode they are naturally deflected out of their path by the electric forces. Goldstein has shown that if the current is equally divided between the two cathodes, the deflection is independent of the intensity of the current, the pressure, and the nature of the gas. This is exactly what ought to happen according to our theory, for strengthening the current at one cathode means, as will presently appear, increasing the velocity of the particles. The square of the velocity will increase in the same ratio as the total fall of potential in the neighbourhood of the negative pole; as the particles pass the other cathode, the forces from it are increased in the same ratio as the square of the velocity with which they are moving, and consequently the path will remain the same. Similarly all the other experimental facts established by Goldstein can be easily explained.

The most conclusive proof of the view adopted in this paper would be found in the demonstration that the amount of electricity carried by each particle was always the same, whatever the current. I propose to test this fact in the following way: It was found by Hittorf that the particles proceeding from the negative electrode, and projected at right angles to the lines of force in a magnetic field are bent round in a circle. This is as it should be, and I calculate that the radius of the circle ought to vary as $\sqrt{F/e}$, where F is the total fall of potential within the region in which the particles acquire their velocity, and e is the amount of electricity carried by each particle. As the current increases, it is shown by Hittorf that F increases; and I find that at the same time the diameter of the ring in the magnetic field increases. If this diameter varies as the square root of F, it would be proved that e must be constant as it is in electrolysis. At present we can only say that the average amount of electricity carried by the particles must increase less rapidly than the fall of potential. If e varies at all, we should expect it to vary proportionally to the fall of potential in the neighbourhood of the negative electrode, and in that case the diameter of the ring would be independent of the current, which it is not.

The theory which I advocate involves the existence of a polarisation, and it might be considered a difficulty that no polarisation currents have with certainty been observed in gases. I believe the difficulty only to be apparent, for the experiments prove that the fall of potential near the negative pole, though rapid, is not sudden, so that the layer within which the condenser action takes place is very much thicker in gases than in liquids. The capacity of the condenser is therefore smaller, and though the total fall of potential in the gas may even be stronger than in the liquid, the polarisation currents might escape observation.

With regard to the positive part of the discharge, it will be sufficient here to mention that stratifications are principally observed in mixtures of gases or in compound gases, and that in the intervals between two stratifications the discharge is very likely carried as through the dark space at the negative electrode, while in the stratifications recombination of the decomposed atoms takes place.

An interesting law has been proved by Hittorf and E. Wiedemann in the case of the unstratified discharge. Hittorf shows that the fall of potential is the same in the positive part for the same tube whatever the current. This means that the energy dissipated is proportional to the current, and not to the square of the current as in a liquid. In the latter form the proposition had previously been proved by E. Wiedemann, who has shown that the total quantity of heat generated is proportional to the total quantity of electricity which has passed through the tube, whether in a few strong sparks or many weaker ones.

These experiments seem to point to the fact that once the original velocity of the particles at the regular pole has been reduced the velocity becomes independent of the strength of the current, that is to say, that in the positive part of the current greater intensity only means a greater number of particles taking place in the discharge.

The paper also contains spectroscopic evidence as to the state of dissociation in a vacuum tube, especially in the negative glow.

The question as to how the electricity passes from the electrode to the gas is not discussed, nor is it possible at present to decide, should the theory prove true, whether the polarity of the atoms in the molecule depends on the way in which these are combined, or whether that atom takes positive polarity which happens to be nearest the negative electrode as the molecule approaches it.

In conclusion some novel influence of the magnet on the negative glow is described, and it is shown that two different effects have to be clearly distinguished. The first is an effect of the magnet on the discharge when that discharge is established, and has been sufficiently well investigated. But the second effect depends on the question from what part of the negative electrode the discharge sets out. With respect to this question we meet with many contradictory and inaccurate statements. If at any place the magnet tends to throw the glow together the temperature will be raised, and owing to this fact the current will be strengthened, which again raises the temperature. It may thus happen that a slight cause can induce the current to pass almost exclusively from one part of the negative electrode. For a detailed description the reader is referred to the paper itself and the illustrations accompanying it.

LEGAL.

Central News v. Eastern Telegraph Company.

This case came on on Saturday morning last, before the Lord Chief Justice, for further consideration on the findings of the jury which took place at the last sittings before his lordship and a special jury in the Queen's Bench Division. The defendants are the Eastern Telegraph Company, Limited, and the Exchange Telegraph Company, and coupled with these defendants were Sir James Anderson, the managing director of the Eastern Telegraph Company, and also at the time in question a director of the Exchange Telegraph Company, and Mr. Benjamin Smith, the chief officer of the former company at Alexandria. The action was brought against these companies and their representatives above named, individually, to recover £10,000, in consequence, as alleged, of the Eastern Telegraph Company having divulged to the Exchange Telegraph Company the contents of a message entrusted to their care at Kassassin by Mr. Burleigh, the special correspondent of the Central News in Egypt during the late war, announcing the fall of Tel-el-Kebir, whereby the Exchange Company were enabled to publish the first intelligence of the issue of that battle, to the detriment of the plaintiffs, in this country. The substantial defence, as our readers already know—*vide Electrician* for May 10th last—was that the news in question was not purloined from the Burleigh telegram, but was gathered from a telegram transmitted by Sir Charles Wilson from Kassassin to Sir Edward Malet at Alexandria, to whom Mr. Benjamin Smith, who was then on board the Eastern Telegraph Company's ship, "John Pender," at once sent it off, and having copied it, sent it as a "service message" by the company's wire *viâ* Malta and Marseilles, and thence to Sir James Anderson, the managing director of his company in London, who, or those who represented him, in turn transmitted it to the Exchange Telegraph Company, which had no correspondent at the front. The Burleigh message was to this effect. "Kebir taken by assault, enemy in full retreat; over 2,000 slain; our loss about 200 killed; forty guns taken; cavalry now in pursuit." This important news was absolutely gathered by Mr. Burleigh on the battlefield, and it was proved that no other correspondent had in his telegram made any allusion either to the guns captured or the number of killed, although these figures were introduced in the telegram sent by Sir Charles Wilson to Sir Edward Malet, and who, it was alleged, had obtained the intelligence from Mr. Burleigh's

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message during the military censorship of all messages from the seat of war at Kassassin. The trial extended over several days, and in the result the jury, answered the questions put to them by Lord Coleridge, firstly that Sir C. Wilson did indirectly make use of the Burleigh message, and secondly that the Eastern Telegraph Company had not divulged the Burleigh message to the Exchange Telegraph Company to the detriment of the plaintiffs. On these findings his lordship reserved judgment, and the case now came on for argument.

Mr. Murphy, Q.C., Mr. H. Dickens, and Mr. A. M. Sullivan were counsel for the Central News (the plaintiffs in the action); the Attorney-General, Mr. Charles Russell, Q.C., and Mr. Moulton were counsel for the Eastern Telegraph Company, Sir James Anderson, and Mr. Benjamin Smith. The Exchange Company was represented by the Solicitor-General, Mr. Bompas, Q.C., and Mr. Jeune.

On the case being called on,

The LORD CHIEF JUSTICE, addressing Mr. Murphy, Q.C., for the plaintiffs, said: I did not give judgment because on the finding of the jury they would not assess any damages, for they found there was no divulgence of the telegram to the detriment of the plaintiffs. I was very anxious that the jury should assess the damages, if any.

Mr. MURPHY: I asked your lordship to direct the jury whether there was any interference with the rights of the plaintiffs in the telegram of which Mr. Burleigh had the property.

The LORD CHIEF JUSTICE: It seems to me that the finding of the jury put you out of court, and I think the best thing I can do is to give judgment for the defendants, and leave you to move.

Mr. MURPHY: If so, may I ask your lordship what was the good of reserving this case for further consideration?

The LORD CHIEF JUSTICE: I am not sure, if you ask me to be candid, that there was any good at all in it. I certainly directed the jury that if there was a message from Sir Charles Wilson to Sir Edward Malet, some of which was taken from the Burleigh message, that of this the plaintiffs had a right to complain. If I was wrong this was misdirection, and you are entitled to a new trial. I will now give judgment on the findings of the jury for the defendants, and on this Mr. Murphy may move for a new trial.

The ATTORNEY-GENERAL: Does Mr. Murphy contend that on the finding of the jury judgment can be entered for the plaintiffs?

Mr. MURPHY: I think not on the findings.

Mr. RUSSELL suggested that on one paragraph, No. 7 in the statement of claim, judgment should be given for the plaintiffs, with nominal damages, this being as regarded the plaintiffs' common law right in the telegram.

Mr. MURPHY: I certainly think I am entitled to judgment on that part of the case. Would it be a convenient course to leave either party to move for judgment?

The ATTORNEY-GENERAL: No.

Mr. RUSSELL: No, no.

Mr. MURPHY: I would rather not have to argue the case before you a second time. I have got a whole battery behind me [laughter].

The LORD CHIEF JUSTICE: I think the most convenient thing is that I should give judgment for the defendants, and then the whole matter can be raised before the Divisional Court.

His LORDSHIP accordingly entered judgment for the defendants.

This decision will be appealed from.

The Lancashire and Cheshire Telephonic Exchange Company (Limited), Appellants, v. the Overseers of Manchester, Respondents.

This case came before Mr. Justice Mathew and Mr. Justice Day in the Queen's Bench Division of the High Court of Justice on the 3rd inst. It was a special case stated for the opinion of the Court upon the question whether a telephone company were liable to be assessed for rates in respect of their telephone posts and wires standing upon ground or attached to buildings of which the company were not occupiers or owners. The Telephone Company carry on business in Manchester, having a central office in the centre of the Exchange system, with wires running thence to the premises of their subscribers. These wires, which are overhead, were erected by the company, but are used exclusively by the subscribers, the wires being attached to buildings or to posts placed on buildings by the consent of the owners or occupiers, and the company's servants can only get at them by entering the buildings upon receiving permission from the owners or occupiers. The wires, posts, &c., of the company had been assessed at £2,000 rateable value, and against this assessment the company appealed, contending that their occupation was not such as to make them liable to rates, being neither exclusive nor permanent.

Mr. Webster, Q.C., and Mr. Henn Collins, Q.C., appeared for the company; Mr. Ambrose, Q.C., and Mr. Smyley for the overseers.

Mr. Justice MATHEW, in giving judgment against the contention of the company, said that the case was concluded by the decision in the case of The Electric Telegraph Company v. The Salford Overseers (reported in 11 "Exchequer Reports," p. 181, in which it was decided that the Electric Telegraph Company were liable to be rated in respect of their wires and posts placed along the lines of railway companies, although the latter could have required their removal to a more convenient place). There the question raised was whether such property was capable of rateable occupation, and the Court held that it was. The case here was the same, the posts and wires were in the exclusive and permanent occupation of the company. There was therefore nothing to distinguish this from the earlier case.

Mr. Justice DAY concurred.

Re Devon and Cornwall Electric Light Company.

On Friday, the 3rd inst., before Mr. Justice Chitty, Mr. Ince, Q.C., moved, on behalf of a Mr. Cadogan, that he be allowed his costs in the suit, and his name struck off the list of contributories on the ground of misrepresentation on the part of the company, who alleged that they had certain special privileges, which was proved not to be the fact. A petition was also presented for the winding up of the company, which was opposed; but when the Court decided that there was misrepresentation the petition was allowed to go after being appealed. It was contended on behalf of the company that the applicant had no right to costs under any circumstances.

Mr. Romer, Q.C., was for the company.

His Lordship refused the application, with costs.

COMPANIES' MEETINGS.

Eastern Telegraph Company (Limited).

The twenty-fourth half-yearly general meeting of this Company was held on Thursday, under the presidency of John Pender, Esq., M.P.

The CHAIRMAN reviewed the financial results of the half year's work as detailed in the report of the directors, and stated that the repairing expenses had been £37,113, being a decrease of £13,788 as compared with the corresponding period of last year. They carried to the general reserve fund £65,000, making that sum, with interest on investments, £614,170, from which amount they had applied £300,000 in part payment for new cables, leaving the general reserve at £314,170. But the total amount of the reserve fund, including the Sardinian cable and other special reserves, was now £349,777. The investments against this were £328,574. In addition to that £100,000 had previously been taken from the fund in part payment of expenditure on account of the Aden-Bombay duplicate cables. Since the amalgamation in 1872 the ordinary working expenses had averaged nearly 26 per cent. of the revenue, and the repairs had averaged 11 per cent. The average amount carried to reserve had been £50,000 per annum. The number of stations in 1881 (to give a review of the last three years) was 42, and in 1884 there were 50. The number of the staff in 1881 was 419, and in 1884, 533. Since March, 1881, they had laid the Malta-Tripoli, the Trieste-Corfu, and the Alexandra-Port Said cables, besides the Suez-Aden triplicate cable and the cable connecting Suakim, being a total length of 2,440 miles. The present length of the cables (including the Black Sea) was about 19,000 miles, and the land lines about 3,000 miles. With regard to the issue of £500,000 of debenture stock at 5 per cent., many thought it a bold thing to offer stock at such a rate of interest, but it had been all taken up, and more would have been taken had they had it to allot. Having given the full details of the manner in which the money so obtained had been dealt with, he alluded to the satisfactory results of the opening of the station at Glasgow. As to the triplicate cable which they had laid in the Red Sea, he thought that step might be regarded as showing a display of foresight, because but for it they could not have given the country the enormous advantage of telegraph communication later on with Suakim. He regarded this as a very important feature in the history of the Company, and they had no reason to regret having carried out this work, as it had already given them a fair return. At their last meeting he had told them that they had made arrangements with the Greek Government for the completion of their system, and that work was all but completed, and when finished they would have connected twenty five islands in Greece with the Government of that country. One of the results of their visit to Constantinople in the autumn had been a concession from the Turkish Government, which gave them in the Mediterranean and the Levant a very strong position indeed. When referring to the Suakim cable he ought to have mentioned that the Government contemplated making a railway from Suakim to Berber. If that were done he had no doubt that Suakim would be a very important point in the Red Sea. He then referred to the preponderating interest which they had acquired in the Direct Spanish Company, and afterwards announced the receipt of a telegram a few minutes previously stating that the necessary authority had been obtained from the Italian Government for completing the purchase of the lines of the Mediterranean Extension Company. During the last three years they had done an amount of work which was simply startling. The average of paying words had been 10,300,000 per annum, the number of non-paying being 3,700,000, or a total of 14,000,000 words per annum, being a daily average, including Sundays, of 38,300. He mentioned this that they might understand how much they were in the hands of the young men who were employed to convey these messages, and in the second place because they could well understand during a time of war what the difficulties of maintaining such a system were. He then alluded to the suit which had been going on between the Company and the Central News, and remarked that he thought in view of what he had just stated the wonder was that the matter had come out as it had done, looking at the fact of the frequent attempts which were made to tamper with their *employés*. He regretted that he could not say the litigation was at an end. He thought the other side had to give them some little credit in face of the difficulties against which the Company had to contend, just as they themselves gave the Central News credit of

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endeavouring to do their work well. He was happy to inform them that their ships at the present moment were not employed, and in the interests of the Company they were well employed when they were doing nothing. He concluded by moving the adoption of the report and the declaration of the dividend and bonus recommended therein, making, with the previous payments, 6 per cent. for the year on the ordinary shares.

The VICE-CHAIRMAN, the Marquis of Tweeddale, seconded the motion, which was carried unanimously after a brief discussion.

A cordial vote of thanks to the chairman and directors was then proposed and seconded, the management of the Company being warmly eulogised.

The CHAIRMAN briefly acknowledged the vote, and the proceedings terminated.

[A full report will appear in our next issue.]

Faure Electric Accumulator Company (Limited).

An extraordinary general meeting of this Company was held on the 9th inst. at the City Terminus Hotel, Mr. Harcourt Turner presiding, to consider the confirmation of the resolution passed at the meeting on the 19th ult. for winding up the Company voluntarily.

The CHAIRMAN stated that the result of the liquidation would be that instead of the directors the liquidators would carry on the affairs of the Company. They would go thoroughly into the accounts, and would have full power to recover any assets. Should it be found that they had any assets—the French patents, for instance—so that the Company could carry on business, the liquidators would call a meeting of the shareholders, with whom the decision would rest whether the Company should be resuscitated, or the assets sold and the proceeds divided. When he went to his office that morning he found a postcard from Mr. Bogler inviting his presence at the meeting to hear an important statement respecting the Company's affairs. He thought it would be advisable that that statement should be made before he put the resolution.

Mr. A. R. BROWN then intimated that he would propose the adjournment of the meeting for fourteen days, and that meantime the resolution for winding up the Company should not be confirmed. Within the last few days important facts had come to his knowledge which led him to hope and believe that the Company might recover its property. He did not believe it would be to the interest of the shareholders that he should disclose at a public meeting the information which had come to him. He would propose that the contract of 1882, made with the Electrical Power Storage Company, by which they ceded their rights and privileges in the the United Kingdom to that company, should be submitted to the Solicitor-General. Counsel's opinion ought to be obtained on it, and if his suggestion were adopted he would be willing to hand the directors a cheque for 200 guineas, or more if necessary, to obtain the high legal opinion he had suggested.

Mr. HENRY STAPLES fully endorsed this proposal, providing the directors saw nothing against it. He had never hesitated to attribute some "hocus-pocus" to the contract, and he endeavoured at the time to elicit from M. Philippart its real nature; but his mouth had been closed by hearing that they were in the hands of M. Philippart. If they found that the sale of their patents to the Storage Company was *ultra vires*, and that no proper consideration was given for them, the agreement might be cancelled by process of law. If they should become possessed of the English patents as well as the French patents—which he maintained were certainly the property of the Company—they would then have something of value.

In reply to a question, Mr. SNELL (the solicitor) stated that nothing had yet been done as to taking counsel's opinion; but he presumed that that would be the first duty of the liquidators after their appointment.

Sir A. J. OTWAY, M.P., thought Mr. Brown's proposal only reasonable, but he would like to know whether the directors saw anything in it which would be prejudicial to the Company's interests. He had had nothing to do with the Company since 1882, but he had always taken a great interest in it. He was satisfied as to the value of the patents; but his information was that the property of the Company had been very improperly parted with, not however in the contract of the date mentioned, but in a contract passed subsequently. It was to be remembered by the shareholders that there had always been this disadvantageous peculiarity about the Company—that more than one-half of the property was held by one person, the individual who had now gone into bankruptcy, and who had been so much denounced (M. Philippart). He at all times had power to do what he chose, owing to the number of shares held by him, and by disseminating them. The old directors nevertheless warned the shareholders against taking the course that gentleman had proposed; but they acted unanimously against the advice of the directors, who then resigned, handing the Company over in a very flourishing condition. The valuable patents and the £23,000 cash had since disappeared, and a later contract had been made signing away their valuable patents. He had received private information which led him to believe that there was very valuable property in the possession of the largest shareholder of the Company (M. Philippart), which property might, by the right steps being taken, be made available to them if the law sanctioned such a proceeding. If the contract which was made subsequent to the one which was ratified by the shareholders should not hold good, they would re-enter into possession of the patents which were made over to the Electrical Power Storage Co. He did not think that anything could touch the contract of July, 1882, because it was made under legal advice, and valuable consideration was given for it. It was also to be remembered that at that time the Faure patents were very much threatened by those who held the Sellon-Volckmar inventions. The secretary would say whether it was right that that contract was submitted to a general meeting.

The SECRETARY (Mr. Herbert Canning) replied that it was "foreshadowed" to a general meeting, not submitted.

Mr. STAPLES repeated that he distinctly endeavoured to elicit information as to what the contract was, but failed.

A letter was then read by the secretary, which had been received from M. Philippart, dated Paris, the 5th inst. He protested against the proposal to go into liquidation, and urged the shareholders to vindicate their right to the exclusive possession of the Faure patents for the whole of the United Kingdom. The Sellon-Volckmar patents were, he wrote, nothing but a counterfeit of the Faure patents, and therefore they received nothing by the first agreement of 1882 with the Storage Company.

The CHAIRMAN pointed out that the adjournment of the meeting would be adverse to the Company's interest, as if there were any delay there was no doubt that others would try and obtain the winding up of the Company.

The resolution was then confirmed, on the motion of the CHAIRMAN; and subsequently a resolution was passed appointing Messrs. F. Cooper (of Cooper Brothers, chartered accountants), H. Canning, and A. R. Brown as liquidators.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. JULY 9.		BUSINESS DONE WEEK ENDING JULY 9. Highest.	Lowest.
Anglo-American	32½,	33½	33¼	32
Do. Preferred	56½,	57½	57⅝	55½
Do. Deferred	7½,	7¾	7¾	7½
Brazilian Submarine	9¾,	10	9⅞	—
Cuba	9¾,	10¼	10	9 15-16
Do. Preference	16½,	17½	—	—
Direct Spanish	4½,	5	—	—
Do. Preference	14½,	14¾	—	—
Direct United States Cable	9⅜,	9⅞	9 15-16	9 9-16
Eastern Telegraph	11,	11¼	11¼	11
Do. 6 per Cent. Preference	13¾,	14¼	14⅛	13 13-16
Do. 5 per Cent. Debentures, 1899	103,	107	106¼	105½
Eastern Extension	11⅜,	11⅝	11⅝	11⅝
German Union	9½,	9¾	—	—
Globe Telegraph and Trust	6⅜,	6⅞	6 13-16	6 9-16
Do. Preference	12½,	12¾	12 11-16	12½
Great Northern	13½,	13¾	13¾	13 9-16
Indo-European	30,	31	30⅝	30½
Mediterranean Extension	1¼,	1¾	—	—
Do. Preference	2,	3	—	—
Reuter's	8,	8½	—	—
Submarine	153,	158	157	155
West India and Panama	⅜,	⅞	—	—
Do. 1st Preference	6,	6½	—	—
Western Brazilian	5,	5¼	5⅛	5
Western Union 7 per Cent. 1st Mortgage	121,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	106	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	¼,	⅜	—	—
Oriental	⅛,	⅜	—	—
United Telephone	9¾,	10¼	10⅛	9¾

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1½,	1¾	1⅝	—
Do. (fully paid)	3,	3½	—	—
Hammond Light (£3 15s. paid)	⅜,	⅝	—	—
Eastern Electric (£4 paid)	—	—	—	—
Swan	⅜,	⅝	½	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	31,	32	32	31½
India Rubber, Gutta Percha, and Telegraph Works	21½,	22½	22⅝	21⅞

TRAFFIC RECEIPTS FOR JUNE, 1884.

COMPANIES.	June, 1884.	June, 1883.	Increase.	Decrease.
Cuba Submarine	3,150	2,688	462	—
Direct Spanish Telegraph	1,345	1,556	—	211
Eastern Extension	31,787	34,307	—	2,520
Great Northern	22,960	—	—	—
West Coast of America	3,615	—	—	—

PHILADELPHIA ELECTRIC EXHIBITION.—WANTED by an Electrician proceeding to above, total or partial CHARGE of EXHIBITS. Can give good references. Address, care Mr. Cheyne, 135, Stamford-street, E.C.

THE ADVERTISER seeks a SITUATION as PHYSICAL DEMONSTRATOR. Has had five years' experience at two colleges. Reason for leaving the present position is the rearrangement of classes. Good practical knowledge of electrical testing. Good testimonials. Address, "Ohm's Law," *The Electrician* Office, 1, Salisbury-court, Fleet-street, E.C.

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NOTES.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 11th July were £2,539.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.—This company will pay a dividend of 12s. per share. The transfer books will be closed up to the 22nd inst.

ELECTRIC LIGHTING IN PHILADELPHIA.—The Brush Company in Philadelphia now have 700 lights at work, and by October next expect to be running as many as 1,200 lamps.

THEATRE LIGHTING.—It is stated that the Ambigue Theatre in Paris is to be lighted by arc and incandescent lamps. Twenty of the former and three hundred of the latter are to be tried at first.

STORMS IN MORAVIA.—According to telegrams from Vienna, violent thunderstorms occurred in the beginning of this week throughout Moravia, many houses being struck by lightning, and several persons injured.

EXHIBITION AT ROUEN.—An industrial exhibition has been opened at Rouen. The interior is lighted by Breguet arc lamps, Swan lamps, and Jablochkoff lamps. Among the exhibits is a small electric railway.

THE LEGION OF HONOUR.—The following gentlemen have been nominated for the Legion of Honour:—Dr. D'Arsonval, of the College of France, a well-known electrician; and M. Postel-Vinay, an electrical engineer.

INTERRUPTION OF TELEGRAPHIC COMMUNICATION.—In the early part of this week telegraphic communication between London and Berlin was partially interrupted, owing to the highly charged state of the atmosphere.

LLOYD'S SIGNAL STATIONS.—A Post Office notice says that the Committee of Lloyd's do not allow their signalmen to signal telegraph messages to passing ships unless the sender has made a previous arrangement with them.

TEMPERATURE OF THE SUN.—Professor de Volson Wood, in an article contributed to *Van Nostrand's Magazine* for this month, concludes that, adopting the method of Pouillet, the temperature of the solar surface is less than 6,000deg. Fahrenheit.

REMOVALS.—The Jarman Electrical Company have removed from Richmond-street, City-road, to Mackintosh-lane, Homerton, E.—The registered office of the British Insulite Company has been removed from 20, Coleman-street, E.C., to Charlton, Kent.

CASTLE STRUCK BY LIGHTNING.—Kranichberg Castle, the summer residence of the Cardinal Prince Archbishop of Vienna, was struck by lightning on Sunday. The apartments usually occupied by his Eminence and the old keep of the castle sustained much damage.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th July are £3,120, as compared with £2,389 in the corresponding period of 1883. The March receipts, estimated at £6,255, realised £6,315.

TENDERS FOR LIGHTING.—The Clevedon (Somerset) Local Board are inviting tenders for lighting the streets of that town for nine months from 15th August next. The number of gas lamps now used is 186. Tenders are to be sent to Mr. H. C. Fry, Clerk to the Board, by the 29th inst.

RESIGNATION.—We are informed that Mr. H. Z. Harold has resigned his post in the firm of Messrs. Johnson and Phillips, telegraph engineers, of Charlton, S.E., and Union-court, Old Broad-street, E.C., with whom for some years he has held a responsible position, and is now about to start in business for himself.

THE MAXIM LAMP IN AMERICA.—The United States Electric Illuminating Company have fitted up the following installations in New York:—New York Press Club, 70 lights; Union Club, 130; Lotos Club, 70; Phœnix Insurance Company, 50; and they also have 227 arc lamps running in various quarters of the city.

INCANDESCENT LAMPS.—Mr. H. B. Gale has made a series of interesting experiments on the efficiency of incandescent lamps, the results of which he has contributed to *Van Nostrand's Magazine.* These experiments were carried out in the Massachusetts Institute of Technology. We shall hope to reprint this paper in an early issue.

A NEW TORPEDO BOAT.—An American paper says:—A new torpedo boat which has recently been exhibited to Government officials at Milford Bay is to be taken to the experimental station at Sandy Hook, where it will undergo still further tests. It is driven and steered by electricity, the operator on shore having perfect control of it, although he may be a mile away.

MEMORIAL TO THE LATE MR. SPOTTISWOODE.—It is announced that this memorial has already reached the sum of £662 10s. The committee are desirous of increasing the amount so as to realise their intention of founding the Spottiswoode Memorial Pension in connection with the Printers' Corporation. Mr. Samuel Spalding, of 147, Drury-lane, is the treasurer to the fund.

INDIA RUBBER, GUTTA PERCHA, &c., COMPANY.—According to the report of this company the business of the past half year has been satisfactory, and the directors will, at the ensuing meeting, recommend the distribution of an interim dividend of 5 per cent., or 10s. per share, free of income tax. The half-yearly general meeting will be held at Cannon-street Hotel on the 22nd inst., at 12 noon.

ELECTRIC LIGHTING IN HANOVER.—The printing establishment of Messrs. Jaenecke Brothers at Hanover has been lighted by incandescent lamps for the last six months. The total number of lights employed is 135, of which 125 are 8 candle-power, eight 10 candle-power, and two 16 candle-power, all Edison's make. The machines used are Schuckert's, made by Uppenborn and Gackenholz, of Hanover.

ELECTRIC LIGHT IN MANCHESTER.—The contract for the lighting of Larard's Still, Oldham-street, which is now undergoing extensive alterations, has been placed in the hands of Mr. F. D'A. Goold, electrical engineer and contractor, 29, St. Mary's-gate, Manchester. The lighting will comprise both arc and incandescent lamps, which will be fed by separate machines. The motive power will consist of an Otto 8 horse-power gas engine.

INSTITUTION OF CIVIL ENGINEERS.—The council of this institution have awarded Mr. Thomas Andrews a Telford medal and premium for his paper on "Galvanic Action between Wrought Iron, Cast Metals, and Various Steels during long Exposure in Sea Water." They have also awarded the Miller Scholarship of £40 per annum for three

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years to Mr. Alfred R. Sennett for his paper on "The Electric Light."

Ship Lighting.—The steamship "Yarra," belonging to the Messageries Maritimes, is lighted by means of 188 Swan lamps, 166 being 10 candle-power and twenty 20 candle-power lamps. Two compound wound Siemens dynamos supply the necessary current. There is also telephonic communication between the bridge and the captain's cabin at the stern. Ader telephones are used, and the captain reports that they have worked extremely well.

Meteorological Forecasts by Telegraph.—The Postmaster-General announces that telegrams containing forecasts of the weather are sent by the Meteorological Office during the harvest, and that such telegrams may, if the addressees make a request to that effect, be exhibited at the local post office instead of being delivered. If one copy is required to be delivered and another to be exhibited an additional charge of 3d. will be made.

A Curious Accident.—A curious accident, says a New York journal, occurred recently on the West Shore Railway, near West Point. The cadets were engaged in target practice with a sea-coast battery, when a shot went 100 yards wide of the mark, striking a steel rail in the centre, bending it in the shape of a letter U, and tearing it from its fastenings. The automatic electric signals used on that section gave warning of the breakage, and the rail was replaced before any further trouble ensued.

Electric Gate Openers for Level Crossings.—A French paper says that the railway companies are about to try an electric gate opener. The method to be tried is briefly as follows:—A catch connected with an electro-magnet keeps the gates closed. An approaching train closes the circuit at a certain distance from the gates, the catch is released and the gates open. When the last carriage has passed the circuit is broken again and the gates close. A bell is also rung as the train approaches.

Fire Caused by Gas.—On Wednesday evening the ventilating shaft above the sunlight in the Royal Albert Hall, South Kensington, was set on fire. Luckily help was close at hand, and the flames were soon extinguished, or history might have had to record the same fate for this building that recently overtook the Brussels Houses of Parliament. Sunlights, as they are called, are prolific causes of fire, and when a few more noble buildings have been burnt down possibly this fact may be recognised and dealt with.

Electric Lighting Provisional Orders.—In the House of Commons, on Thursday, the 10th inst., in answer to Mr. W. Fowler, Mr. Chamberlain said: One hundred and twenty applications for provisional orders have been made to the Board of Trade since the passing of the Electric Lighting Act. Of these seventy-three have been granted by the Board of Trade and confirmed by Parliament. There have been ten applications for licences. One for Colchester will be granted in the course of a few days. The remainder have not been proceeded with by the applicants. The supply of electricity has not been commenced under any of the orders.

Society of Chemical Industry.—On Wednesday, the 9th inst., the annual meeting of this society was opened at Newcastle-on-Tyne. The president, Mr. W. Weldon, occupied the chair, and amongst those present were Dr. Perkin, and Professors Roscoe, Huntington, and Armstrong. The report of the council announced that the members now numbered 1,809, against the 297 who formed the nucleus of the society when started in 1881. The president then delivered his address, which related chiefly to the soda industry and the recent chemical improvements connected with it. Subsequently the members paid visits to the chief works in the neighbourhood.

Underground Wires.—At the last meeting of the New York Electrical Society, Mr. Sinclair, of the United States Experimental Station (for gunnery) at Sandy Hook, gave a short description of the Howe system of underground wires in use by them. He said it was simply a covering of composition of tar, rosin, &c., surrounded with braided cotton, and then painted. Wires thus prepared were then laid in a trench 4ft. deep on a board, and fastened with a wooden cleat about 1in. apart. They were covered with another board, and the trench was refilled with sand. These wires, he said, have worked satisfactorily through the winter, with the ground in some places covered with water and ice.

Eastern Telegraph Company.—Some interesting information concerning this company will be found in our detailed report of the half-yearly meeting of the shareholders. Thus it appears that the number of stations increased from 42 in 1881 to 50 in 1884, and that the staff, in like manner, had increased from 419 in the former year to 533 at the present time. The company have laid the following cables since March, 1881, viz.:—Malta to Tripoli, 204 miles; Trieste-Corfu, 303 miles; Alexandria-Port Said, 153 miles; Suez-Aden, 1,402 miles; connection with Suakim, 178 miles, making a grand total of 2,440 miles. The company now owns 19,000 miles of cable and 3,000 miles of land lines.

Indian and Oriental Electrical Storage Company.—The following is the minute giving particulars of the affairs of this company required by the High Court of Justice before allowing a reduction of capital:—"The capital of the Indian and Oriental Electrical Storage and Works Company (Limited) is £280,000, divided into 10,000 deferred shares of £3 10s. each, and 70,000 ordinary shares of £3 10s. each. At the time of the registration of this minute (July 11) none of the deferred shares have been issued; the sum of £2 5s. has been called up upon each of 30,000 of the said ordinary shares, and the sum of £3 10s. is to be deemed to be paid up upon each of the other 5,000 ordinary shares; and none of the remaining 35,000 ordinary shares have been issued." The original capital of the company was £400,000; according to the above minute it will now be £280,000.

Dry Batteries.—MM. Becquerel and Onimus have been experimenting on dry batteries. Many have endeavoured to obtain a dry cell by mixing sand with chlorhydrate of ammonia. The two above mentioned obtain a modification of this process by mixing plaster with the exciting liquid, and then allowing it to solidify. As this plan can only be adopted with those cells which work only when the circuit is closed, the chlorhydrate of ammonia and chloride of zinc cells are the only ones that can be used to any advantage. Instead of using plaster only, MM. Becquerel and Onimus sometimes mix peroxyde of manganese or sesquioxyde of iron with it. In these cases the E.M.F. is slightly greater. When the battery has run down, all that is required is to moisten with more exciting liquid. The common defect of all dry batteries is that the quantity of exciting liquid being a minimum, the total electrical energy they are capable of furnishing before being recharged is also a minimum

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DEATH OF M. L'ABBE MOIGNO.—This celebrated man, both theologian and scientist, died at Paris on Sunday last. His loss will be severely felt, not only in French circles, but outside his own country. He was a marvellously fertile writer, and wrote a great deal for the press and periodical literature. He established a scientific periodical of his own, which he named the *Cosmos*. To this he added the sub-title of *Les Mondes*, by which it is better known at the present day. The Abbé was the descendant of an old Breton family, and was born at Guemenee in 1803. He was taught mathematics at the Jesuits' College in Paris, but one of his treatises being disapproved of by his superiors, he resigned his post, and took to writing scientific articles for newspapers. He was assistant-chaplain at a Paris Lycée, and in 1873 was appointed a canon of St. Denis. He spoke a dozen languages, had a wonderful memory, and in his younger days was acquainted with Humboldt, Arago, and other eminent men of science.

ELECTRIC LIGHTS FOR LIGHTHOUSES.—General Duane has, since August last, been carrying out a series of experiments as to the applicability of electric lights for lighthouse work for the United States Lighthouse Board. The experiments have been carried out at Tompkinsville, Staten Island, the electrical portion being under the charge of Lieut. John Millis. The present result of the experiments is that the electric light is found to be ten times more powerful than the oil light, and that for a given amount of light it is the cheaper of the two. It is said that of the apparatus tried the most useful has been found to be that at present in use in the French lighthouses. Among the dynamos tried have been the Gramme, Elphinstone-Vincent, Siemens, and Weston. The report on these experiments is not expected to be ready for some months yet, but when it does appear it will be of the greatest interest. If the report of the committee now engaged in the same kind of experiments for the Trinity House at the South Foreland should appear contemporaneously with that of General Duane, some interesting comparisons might be made.

DOMESTIC LIGHTING.—Our contemporary, *L'Electricien*, in its last issue, gives some particulars of the lighting of M. Gaston Menier's house. The installation comprises 150 forty-volt Swan lamps, requiring ·7 ampere of current, which are fed by 22 Faure-Sellon-Volckmar accumulators of the 60 kilogram type, mounted in series. These accumulators will give normally from 40 to 45 amperes, or sufficient current for 60 lamps at once. They are charged every day by a Gramme continuous current self-excited machine. This is driven by an Otto gas engine of five horse-power. With a little practice the servant who has charge of the lighting estimates with sufficient accuracy the night's consumption in ampere hours, and recharges the accumulators with just the amount expended, allowing them about 10 to 15 per cent. extra to make up for losses or errors. Suppose, for instance, that during the night 60 lamps have been alight for 4 hours. The total consumption in ampere-hours will have been:—$60 \times \cdot 7 \times 4 = 168$ ampere-hours. He will charge the accumulators on the following day for about 5 hours with a current of 40 amperes, or, in other words, $40 \times 5 = 200$ ampere hours. The accumulators which have been in use for six months or more have only required partial renewing. Our contemporary thinks that this method of running lamps from accumulators is preferable and more economical than that of feeding them direct from the machine, even though the first cost of the accumulators is by no means a small item.

THE NEW STANDARD OF LIGHT.—The practical difficulties in the application of the new standard of light fixed upon by the Paris Congress are likely to prevent its extended use. Dr. Werner Siemens suggests the following modification of this standard, viz., that instead of measuring with the aid of a surface of liquid platinum on the point of solidification, we should measure with solid platinum on the point of liquefication. If the solidifying and melting point of platinum are identical, his method would give absolutely the same results as that of the Paris Congress. If, however, further researches should prove that platinum melts at another temperature than that at which it solidifies, then a correction will have to be made by introducing a coefficient, expressing the proportion between the light emitted by platinum at these two temperatures. The apparatus of Dr. Werner Siemens consists of a closed metallic box, within which a thin strip of platinum foil 6 mm. wide and 0·02 mm. thick can be heated by a current from some cells. A circular opening in one of the sides of the box of exactly 0·1 square centimetre area allows the rays of light from the incandescent platinum (which is immediately behind the opening) to pass out to the photometer. In taking a measurement the current is gradually increased, and the screen of the photometer gradually shifted so as to maintain always a photometric balance between the platinum and the source of light which is to be measured. The position of the screen at the moment when the platinum lamp is extinguished—that is, at the moment when the foil has melted—gives the value of the light measured in new standard units. The platinum foil is coiled upon a small drum, and by means of a set of levers moved by a handle from the outside of the box, a new surface of the foil can immediately be brought before the opening in readiness for another measurement.

PROTECTION FROM LIGHTNING FOR OIL TANKS.—The fires that have occurred in the oil regions of America through oil tanks being struck by lightning, have raised some discussion as to the best protection for these tanks. Mr. Oberlin Smith writes to the Chicago *Industrial World* on the subject, and offers a suggestion. Accepting the theory that the vaporisation of the oil creates a lofty column that acts as a kind of lightning rod, he contends that the way to meet the difficulty is to run a rod or metallic conductor high enough to overtop the inflammable column of vapour, with branches extending laterally to protect against lower clouds that might discharge their lightning in a partially lateral direction. It is said that the lightning at Point Breeze, Philadelphia, where twenty large tanks were recently destroyed, caused an explosion in the air at a height estimated to have been from 100ft. to 300ft. Mr. Smith says: "I do not know whether any experiments have been made with regard to the height and inflammability of these vapour columns; undoubtedly there is a height where the gas is so diluted by air as not to be combustible. Guessing at the subject, it would seem as if a rod extending 300 or 400 feet high might protect a considerable area of oil-yard. A friend at my elbow suggests a construction something like the electric light towers used by some of the lighting companies. The expense of this would not be worth consideration compared with the loss sometimes occasioned by one stroke of lightning, and such a tower might be utilised for lighting the oil works by arc lights in the usual manner. At the top of the tower, a rod cheaply made of gradually reducing gas pipes could be extended a good many feet above the summit, to still further lessen the danger. Of course such a tower should have ample metallic connections with an extensive system of underground water pipes, and all joints should be made with as perfect contact as possible."

WILKINS'S TELEGRAPH.—In turning over the pages of Vol. II. of the *Journal* of the Society of Arts for 1853-4, we came

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across the following description of the recording telegraph designed by Mr. J. J. Wilkins, which is additionally interesting as containing a reference to Davey's telegraph, described by Mr. Fahie in our eleventh volume. The description is as follows, *vide* p. 135 of above journal:—"A point or marker is held by a spring in contact with a ribbon of paper against a marking surface, and if the marker were moved by the hand, lines of any form might be traced. The marker is mounted upon an iron armature between four poles of two electro-magnets placed *vis-à-vis*. The armature is fixed on a centre between the poles, and attracted each end in an opposite direction. The armature being at rest, equidistant between the magnets, it follows that while the ribbon of paper is travelling between the marker and the marking surface, a line is drawn in the middle of the paper, and any diversion of the armature from the position of rest entails a corresponding diversion of the line drawn, and by the number and form of such diversions the message is composed. The automaton repeater connected with this telegraph is an apparatus devised to carry out the objects of Davey (who, to a certain extent, succeeded to work (*sic*) a telegraph recording instrument), and to act as a relay of power to work other circuits. This instrument, as now constructed, enables the longest circuits to be telegraphed over at once without the operation of repeating. The telegraph is one-wired, and one operator only is necessary. This advantage would recommend it were expense only considered, but the addition of greater certainty is secured likewise. The insulator is a means evident to the most ordinary capacity of accomplishing the insulation of overground wires. November even at the present day (January, 1854) is the purgatory of telegraphs."

THUNDERSTORMS.—On Friday, the 11th inst., a house in the Westmuir of Kirriemuir was struck by lightning. The lightning entered by the kitchen chimney, shattering to pieces a clock, passed to another room, the window of which it smashed to atoms, and then escaped through the roof, damaging the ceiling considerably. The wife of the occupant and her children were at the time seated at the kitchen window, but fortunately escaped uninjured.—A heavy storm of thunder swept over Durham and district on Sunday night about eight o'clock. A contemporary says that at the height of the storm a fire-ball fell on to the road, in front of a number of people who were sheltering in Oswald-court, Church-street. It burst into a myriad of jets of fire, and emitted a strong sulphurous smell, the lights being of dazzling brightness. No damage was done to the roadway where it fell. The thirty or forty people who saw it, however, fled in all directions, notwithstanding that the rain was falling in torrents. At the colliery village of Shield Row, in north-west Durham, a boy was struck by the lightning and killed on the spot.—At Birmingham Barracks, on the same day, a chimney was struck.—On Sunday afternoon, during the races which were being held at Barmen, near Elberfeld, a thunderstorm occurred, and the lightning struck a circus while the performance was going on, with the result that four persons were killed and seven severely and many others slightly injured.—During a storm which passed over the North Riding of Yorkshire on Sunday night the vicarage of Osmotherly was struck by lightning, and the gable end carried away and other damage inflicted. A cottage near Sutton was struck and the furniture destroyed. Some farm buildings belonging to Mr. Carver, at Thirlby, were unroofed, and clover and haystacks swept away. The lightning struck the workhouse at Guisborough, entering a room in which there were eighteen females sleeping. The ceiling was damaged, a water pipe in the room broken, and one of the beds scorched, but the inmates were unharmed. At Mickleton-in-Teesdale twelve sheep were killed.

EFFECTS OF LIGHTNING.—Mr. Worthington G. Smith writes to *Nature* as follows:—"On June 6th, 1881, I was in the open country, near the sea, between Gosport and Southampton, in a place where there was no shelter. Here I was suddenly overtaken by a violent storm of thunder, lightning, and rain. Before I had time to think of escape the air became darkened by the pouring rain, and to save myself from a drenching I, perhaps foolishly, put up my umbrella. At the same instant I saw a blaze of fire on the right hand side of my face; the thunder burst at the same moment, and a violent wrenching pain seized the fingers of my right hand (which held the umbrella), the pain instantly travelling to my elbow and shoulder, where it ceased. With the exception of a strong pain in the arm like rheumatism for the rest of the day, I felt no further ill effects. There is a blind beggar sometimes seen about here [our contemporary omits Mr. Smith's address, but we gather from his letter that it is somewhere between Gosport and Southampton], who carries a label stating that his eyes were destroyed by lightning. There is no iris to either eye; both are quite white. One day lately I asked him how he lost his sight. He said that he was leaving a country public house during a thunderstorm, and he received the blow from the lightning at the street door as he stood on the top of a short flight of stone steps. He could only remember seeing the blaze of the lightning and being hurled to the ground down the steps into the street. On his senses returning he was blind. He states that he had a little glimmering sight at the time of recovery, but first one eye and then the other soon became totally blind." Mr. Smith also mentions that on the 5th July, 1881, at 11:30 p.m., he saw a ball of fire drop from the clouds to the earth. The descent was rapid, but not comparable with lightning, and with an inclination to the east. The ball appeared large, and about $\frac{1}{2}$ or $\frac{1}{3}$ the apparent size of the moon. Mr. Smith mentions that this ball of fire was also independently observed by another man at the same time.

ELECTRIC LIGHTING FOR DANCES.—Two dances given by Mrs. Mendl, of 39, Holland Park, on Tuesday and Thursday, were much enhanced by the rooms being lighted by incandescent lamps. Although both evenings were extremely hot, the rooms, as usual when lighted by the electric light, were not nearly so close as when lighted by gas on a cool evening. The following particulars may be of interest:—The size of the dining room was 27ft. by 16ft. by 13ft. high; this being merely a refreshment room was underlighted, except at the extreme end over the table, where there were two 20 and one 10 candle-power lamps. At the other end of the room there was only one 20 candle-power lamp. The drawing room, where the dancing took place, was 34ft. by 19ft. by 13ft. high; this room was brilliantly lighted. There were twelve 10 candle-power lamps in the centre chandelier, three 20 candle-power lamps hanging from pendants in the centre of each window, one on a statue underneath, and one 20 candle-power lamp at the further end lighting up the conservatory as well as one end of the room. One 20 candle-power lamp was arranged under water in the conservatory. The hall was well lighted by one 20 candle-power lamp in front and one 10 candle-power lamp behind, the size being 32ft. by 7ft. by 10ft. high. The supper-room upstairs, 27ft. by 16ft. by 10ft. 6in. high, was very brilliantly lighted with six 20 candle-power lamps hung as pendants, with small globes. The lamps being of the new Woodhouse and Rawson type took very little current. From 9:30 to 12 o'clock—that is, before the supper room was

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lighted—15 amperes were required; from 12 to 2:30, 21 amperes; from 2:30 to 3:50, 15½ amperes. On the second night the current was slightly in excess of this, there being more cells switched on. Thirty-one horse-power Faure-Sellon-Volckmar cells were used, and the total number of ampere hours taken out of them was 252. The lamps were running somewhat over 20 and 10 candle-power. The lamps, instruments, wires, &c., were supplied by Messrs. Woodhouse and Rawson, and the installation was superintended by Mr. E. Manville.

The Swan and Edison Works at Newcastle.—The Association of Sanitary and Municipal Engineers opened their annual meeting last week at Newcastle-on-Tyne, under the presidency of Mr. W. G. Laws, the borough engineer of that town. Among the works visited during the course of the meeting, which extended over several days, were those of the Edison and Swan United Electric Light Company. We extract the following account of the visit from the *Newcastle Chronicle*:—"This establishment is rigorously closed to the public, and the privilege of inspecting the modes by which the Swan incandescent lamps are made has very rarely been accorded to any number of persons. The industry is an entirely new one, and machinery and tools have had to be invented for carrying out its processes. Many of the work-people employed are Germans, and the rules and instructions for the guidance of the hands are in several cases printed or painted in two languages. The members of the visiting party were conducted over the greater part of the establishment, and were shown the means by which the filaments and platinum wire attachments were prepared and fitted into the now familiar lamps. The next section of the work inspected was that connected with the exhausting of the atmospheric air from the lamps and the securing of a non-conducting vacuum in their interior. A most ingeniously designed machine is used for this purpose, and the visitors spent a large proportion of the time at their disposal in examining its plan and mode of operation. Finally, the party was conducted to the testing rooms, where the lamps were seen lighted on a frame so placed that the rays from each were thrown through a slit on to a screen in a darkened chamber. In this recess a youth separately compared the lights with the illumination given by a standard lamp, and called out the result as 'bright,' 'dull,' or 'standard,' as the case might be. In the manager's office were shown a number of very beautiful coloured lamps, and, much more interesting, the apparatus respectively used for measuring the strength of the currents generated by the supplying machinery, and the intensity of the illumination produced."

Magnetism of Organic Bodies.—Herren Wleügel and Henrichsen have investigated this subject and communicated their results to *Wiedemann's Annalen*. We condense the following from a translation in the *Phil. Mag.* for July:—"The authors have examined the magnetism of some compounds of the alcohol radicals C_nH_{2n+1}. The bodies in question, which were partly prepared by the authors themselves and partly obtained from M. Kahlbaum, were all carefully purified before being used. For the measurements, they were placed in a small glass vessel. This was of a somewhat long horizontal shape, and had a bifilar suspension, so that it oscillated between the pointed half-armatures of a large horseshoe electro-magnet. The current was that of 16 – 18 Bunsen's elements. The magnetism excited in the bodies was measured by a torsion method with a mirror reading like that previously used by G. Wiedemann. The results are collated in the following table; *m* is here the specific magnetism, that of water being – 100, μ is the molecular magnetism, and *q* the molecular weight. The negative prefix indicates diamagnetism. The magnetism of the displaced air was taken into account. The numbers here given are only provisionally to be considered as correct, as the authors wish once more to test the purity of the substances used. They are, however, sufficiently trustworthy to justify several interesting conclusions:—

	m.	μ.	*q.*
Methylic alcohol	– 94·40	– 3021	32
„ iodide	58·01	8238	142
„ sulphate	102·34	6345	62
„ acetate	80·90	5987	74
Ethylic alcohol	101·09	4759	46
„ iodide	61·96	9665	156
„ bromide	68·90	7511	109
„ sulphide	105·48	9493	90
Propylic alcohol	107·51	6451	60
Isopropylic alcohol	107·51	6451	60
Propylic iodide	66·65	11331	170
„ bromide	74·48	9161	123
„ chloride	100·08	7857	78·5
„ sulphide	107·84	12729	118
Isobutyric alcohol	109·80	8125	74
„ acetate	96·07	11167	116
Water	100	1800	18

Accident from Lightning in America.—The Rev. H. C. Hovey writes to the *Scientific American* giving an interesting account of the effects of a lightning stroke at the new drill hall of the State University at Minneapolis on June 12:—"At 2 p.m. there were 1,000 children assembled on the stage of the hall, and about 3,000 persons in the audience. A thunderstorm arose, and while the children's choruses were going on it was noticed that the series of electric lamps, fifteen in number, hanging from the dome, were lighted at each flash of lightning, going out again at once, and a sense of uneasiness pervaded the people. Herr Scaria had just opened the rear door of the stage, a solo from him being next in order, when suddenly there was a loud report, as if of heavy ordnance, balls of fire were distinctly seen through the large skylight, and following the electric wires away from the building. Subsequent examination showed that the lightning first struck the flagstaff surmounting the door, thence pierced an oaken beam to which the staff was fastened, the splinters, or the concussion, breaking the glass in the skylight. An iron rod conducted the current to the network of electric wires below, where the charge was divided, a portion being harmlessly distributed over the general circuit, and the remainder shattering several electric masts near the building. What drew the lightning was the metallic ball surmounting the tall flag-staff, fifty feet from the wires, and not the wires themselves. There is not the slightest doubt, says Mr. Hovey, that these latter performed the duty of lightning rods in this instance, although not put up for that purpose. Mr. Noyes, foreman of the Brush Company, tells an interesting experience. He was at work on the wires previous to the storm, and kept on after it burst, although aware of his danger. At the moment the building was struck he was splicing the wires directly above the central lamp, meanwhile taking every precaution possible under the circumstances. For a few minutes he lay unconscious, and then regaining his senses descended to the ground. He says that he did not feel any pain until he reached *terra firma*, when he suffered intensely in his right foot. On examination he found that the bolt had struck his leg below the knee, tearing the clothing to shreds, bursting open his stout boot from heel to toe, and blistering the flesh as if with a hot iron.'

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ELECTRO-CHEMISTRY.—Inorganic.

BY DR. G. GORE, F.R.S.

(CONCLUDED FROM PAGE 199.)

In a third similar experiment, by using a large sheet platinum anode and a small platinum cathode, and a current from ten Smee's cells during two hours, the phenomena were the same as in previous experiments. The anode lost 28 grains; much loose platinum collected on the cathode, which was neither corroded nor alloyed. The saline residue contained a trace of dissolved platinum salt, and nearly all the corroded platinum in a metallic state. In a fourth experiment I continued the action during three and a half hours; the results were as before. The loss of the anode was 35·73 grains. The saline residue contained a small quantity of dissolved double fluoride of platinum and potassium, which, after being well washed, was dried and heated to redness; it then shot about as if gas was evolved from it. In a fifth similar experiment, lasting four and a half hours, at the lowest possible fusion temperature, more of the brown platinum salt formed at the anode and dissolved in the liquid. The anode lost 64·81 grains. In a last experiment I electrolysed a gently fused mixture of 900 grains of the pure double salt and 100 grains of pure argentic fluoride, with a large anode of platinum and a large cathode of silver. Conduction was complete with ten Smee's cells. No gas was evolved at either electrode. The surface of the anode disintegrated rapidly and lost 49·84 grains in four and a half hours' action. The separated platinum dissolved only to a small extent in the liquid, and subsided in admixture with the silver to the bottom of the vessel as a fine, black powder, weighing 73·93 grains, which lost less than two per cent. when heated to redness. Some grey silver powder was deposited upon the cathode. In all these experiments with the acid fluoride, saline films continually formed upon the surface of the liquid. They came from the cathode and were more abundant the deeper the cathode was immersed.

I electrolysed a nearly saturated aqueous solution of pure fluoride of potassium by means of a current from six Grove cells with large platinum electrodes. Conduction was copious, and the liquid acquired a nearly boiling temperature. Much gas, having an odour like that of a mixture of ozone and chlorine, was evolved at the anode. A saturated solution of the same salt, electrolysed by a current from ten large Smee cells with large platinum electrodes, evolved gas at each electrode. That from the anode smelt powerfully of ozone, and reinflamed a red hot splint. Several other experiments with variations in the size of the electrodes were made, and with addition of hydrofluoric acid, but the results were similar.

I saturated some pure dilute hydrofluoric acid of 40 per cent. at 60° F. with pure double fluoride of hydrogen and potassium, and electrolysed the solution by a current from 10 Smee's cells, a gold anode, and a platinum cathode, during 5½ hours. Gas was evolved freely from both electrodes, and a strong odour of ozone was observed. The anode lost 1·73 grain, and the cathode acquired first a gilded appearance and then a black coating, and the liquid became black with finely divided matter.

Electrolysis of Potassic Chloride. — KCl. Molecular weight = 74·6. Matthiessen separated the metal from this salt by means of a current from six Bunsen's elements with carbon electrodes. He melted a dry mixture of one molecular weight of potassic chloride and one of calcic chloride, arranging the distribution of the heat so that a little of the mixture remained unfused around the upper part of the cathode. Chlorine escaped at the anode, and pure potassium accumulated around the anode beneath the crust. The crucible was then cooled, and its contents removed under rock oil (Watts's "Dictionary of Chemistry," Vol. IV., p. 692.)

Electrolysis of Potassic Chlorate.—$KClO_3$. Molecular weight = 122·6. According to Brester, the electrolysis of melted potassic chlorate, with a platinum anode, yielded potassium, which united with a cathode of copper or platinum. Chlorine and oxygen, with an odour of phosphorus, were set free at the anode, and formed thick white vapours by contact with water (*Chem. News*, Vol. XVIII., p. 145).

Electrolysis of Potassic Iodide.—KI. Molecular weight = 166·1. According to H. St. Claire Deville, silver renders a solution of potassic iodide alkaline by simple immersion in it; it also liberates potassium by a similar reaction when immersed in the fused salt (*The Chemist*, New Series, Vol. IV., p. 329). I have noticed that mercury, by prolonged contact with a perfectly neutral solution of the salt, renders it faintly alkaline. Faraday found that by passing an electric current through melted iodide of potassium, iodine was set free at the anode and potassium at the cathode.

Electrolysis of Potassic Carbonate.—K_2CO_3. Molecular weight = 138·2. By the electrolysis of solutions of hydropotassic carbonate, carbonic anhydride is very incompletely evolved at the anode (C. Luckow, *Jour. Chem. Soc.*, Vol. XXXVIII., 1880, p. 283). According to Faire and Roche, in the electrolysis of solutions of alkaline carbonates or bicarbonites, the molecule splits up in such a way that an atom of potassium or sodium is set free at the cathode, and liberates hydrogen (*Chem. News*, Vol. XXX., p. 63; *Jour. Chem. Soc.*, Vol. XII., p. 861).

Electrolysis of Potassic Cyanide.—KCy. Molecular weight = 65·1. According to H. St. Claire Deville, even platinum, in a state of fine powder, when immersed in a boiling hot solution of this salt, liberates hydrogen. By the electrolysis of a solution of potassic cyanide, Kolbe observed that potassic cyanate was formed at the anode (Watts's "Dictionary of Chemistry," Vol. II., p. 190). Faraday noticed that the aqueous solution yielded by electrolysis hydrogen and potash at the cathode, but no oxygen at the anode; that the liquid around the anode became brown, that the fused salt, and that aqueous solutions of potassic sulphocyanide and ferrocyanide behaved similarly (Gmelin's "Handbook of Chemistry," Vol. I., p. 458).

Electrolysis of Potassic Ferrocyanide.—KFCy. Molecular weight = 368. When a solution of ferrocyanide of potassium is decomposed by an electric current, ferricyanide of potassium is formed at the anode, and hydrogen and potash appear at the cathode (Watts's "Dictionary of Chemistry," Vol. II., p. 240). The alkaline ferrocyanides yield alkali at the cathode, and hydrocyanic acid and Prussian blue at the anode, unless the anode is composed of copper, in which case a deposit is there formed of cyanide of copper (Porrett, *ibid*, p. 222).

Electrolysis of Potassic Ferridcyanide.—KFdCy. Molecular weight = 329. Carbon charged with hydrogen easily reduces a solution of ferri to ferro-cyanide of potassium (Gladstone and Tribe, *Jour. Chem. Soc.*, Vol. XXXIII., 1878, p. 309). A platinum hydrogen couple does the same readily (*ibid*). Bottger observed a similar effect with palladium containing occluded hydrogen.

When a solution of potassic ferricyanide is electrolysed by a separate current, yellow prussiate is formed upon the cathode (Watts's "Dictionary of Chemistry," Vol. II., p. 247).

Separation of Rubidium.—Rb. Atomic weight = 85·48. A monad cation. Like sodium and potassium, this metal is separated from its fused carbonate at a white heat by simple contact with carbon. It was first obtained by electrolysing its fused chloride with a graphite anode, and a cathode of iron wire. It has been obtained by electrolysing a fused mixture of the chlorides of rubidium and calcium in their equivalent proportions at a temperature a little below redness. It is also obtained as an amalgam by electrolysing a strong neutral aqueous solution of rubidium chloride with an anode of platinum and a cathode of mercury. The metal itself is decidedly more electro-positive than potassium, and both it and its amalgam decompose water readily (Watts's "Dictionary of Chemistry," Vol. V., p. 129).

Separation of Caesium. — Cs. Atomic weight = 132·66. A monad cation. Unlike rubidium, potassium, and sodium, this metal is not liberated from its fused carbonate by contact

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with carbon at a white heat. An amalgam of the metal may be easily obtained by electrolysing a solution of caesium chloride with a cathode of mercury (Watts's "Dictionary of Chemistry," Vol. I., p. 1,114). M. Setterberg obtained metallic caesium by electrolysing a dry mixture of four parts of caesium cyanide and one of barium cyanide. This mixture fuses more easily than caesium cyanide alone (*Chem. News*, Vol. XLV., p. 94, and Vol. XLVI., p. 249).

Separation of Ammonium (?), H_4N_1, and Electrolysis of Ammonia.—H_3N. Weyl, in 1864, discovered that sodium swells, liquefies, and dissolves in anhydrous ammonia liquefied by pressure, and on removal of the pressure the sodium returns to the metallic state; also that potassium behaves similarly; that barium forms a deep blue liquid with a metallic lustre; and that silver, mercury, copper, and zinc likewise form unstable compounds with the liquefied gas (Watts's "Dictionary of Chemistry," Vol. V., pp. 328-329). Seeley in 1870 subsequently discovered that metallic rubidium, potassium, sodium, or lithium, by simple immersion in colourless anhydrous ammonia liquefied by pressure, dissolved in the liquid, and produced intensely blue solutions of powerfully reducing properties (*Chem. News*, Vol. XXIII., p. 169, Watts's "Dictionary of Chemistry," Vol. VI., p. 60). I have also verified these results, and have examined the action of the sodium solution upon various compounds (*Proc. Roy. Soc.*, Vol. XXI., 1873, pp. 140-147). In all these blue solutions it is supposed that ammonium is set free and dissolved.

Bleekrode ascertained that anhydrous liquefied ammonia was a conductor and an electrolyte. He passed the current from 80 Bunsen cells through it; gas was evolved, and the liquid became intensely blue. He also passed the current from 3,240 cells of De la Rue's chloride of silver battery through the liquid by means of platinum wire electrodes. The anode became black, much gas was evolved, and the liquid became intensely blue. On stopping the current the colour disappeared. In these experiments ammonium was probably set free and dissolved, and produced the colour.

Damp iron filings exposed to the air or to nitrogen induce the formation of ammonia (Berzelius).

Electrolysis of Aqueous Ammonia.—By simple immersion of magnesium in solutions of ammonium salts, ammonia and nitrogen are set free (S. Kern, *Jour. Chem. Soc.*, 1876, Part II., p. 479). By electrolysis of ammonium salts ammonia is produced at the cathode (C. Luckow, *Jour. Chem. Soc.*, Vol. XXXVIII., 1880, p. 285). According to Hisinger and Berzelius a concentrated aqueous solution of ammonia conducts as imperfectly as pure water, but by addition of a little ammonic sulphate it is rendered easily decomposable. A gold anode becomes covered with amber coloured fulminate of the metal and dissolves, and the cathode is gilded. With a mixture of one volume of strong aqueous ammonia and three of water, oxygen is set free at the anode, and the anode becomes corroded. With a cathode of mercury, the bulky "amalgam of ammonium" is obtained (Gmelin's "Handbook of Chemistry," Vol. I., p. 458).

According to Favre, under the influence of the current, ammonic oxide is decomposed thus:—1st, $3\ (NH_4)_2O = 3\ (NH_4)_2 + O_3$. The three equivalents of ammonium set at liberty decompose the water, like potassium or sodium, thus:—2nd, $3\ (NH_4)_2 + 3\ H_2O = 3\ (NH_4)_2O + 3\ H_2$. The oxygen of equation No. 1, reacting upon the ammonium, gives:—3rd, $O + NH_4 = N + 2\ H_2O$. The first equation represents the electrolysis proper (*Jour. Chem. Soc.*, Vol. IX., p. 985).

The so-called "ammonium amalgam" with mercury was discovered in 1800 simultaneously by Seebeck, in Jena, and by Berzelius and Pontin at Stockholm. It is obtained either by the contact of sodium amalgam with strong solution of certain salts of ammonia, or by the electrolysis of a concentrated solution of sal-ammoniac, or certain other ammoniacal salts (not the nitrate) with a cathode of mercury. In each case the mercury swells to a bulky mass, which on the cessation of electrolysis, spontaneously decomposes into liquid mercury and a mixture of two volumes of ammonia and one of hydrogen. It solidifies below 0°C., and crystallises in cubes. It does not decompose below 29°C. if previously frozen. In the separate current process oxygen is evolved at the anode, if the salt employed is aqueous ammonia, or the carbonate, sulphate, or phosphate, but chlorine if it is sal ammoniac, and but little gas is set free at the cathode (Watts's "Dictionary of Chemistry," Vol. I., p. 188). If the cathode consists of spongy platinum impregnated with mercury, much gas is evolved and no amalgam is formed (Wetherill, *ibid*, Vol. VI., p. 103). A concentrated solution of trimethylamine hydrochloride behaves with sodium amalgam just like one of sal-ammoniac (Pfëil and Lippmann, Watts's "Dictionary of Chemistry," Vol. VI. p. 104). Various investigators consider the ammoniacal amalgam to be merely a spongy mixture of mercury and hydrogen (*see* Seeley, *Chem. News*, 1871, Vol. XXIII., p. 169; also Pfëil and Lippmann, Watts's "Dictionary of Chemistry," Vol. VI., p. 104).

Electrolysis of Nitrate of Ammonia.—NH_4NO_3. Molecular weight = 80. The action of a copper zinc couple on a solution of ammonium nitrate showed that both nitrate and ammonia were produced. In the cold the nitrate, even in a solution of 20 per cent., was completely reduced to ammonia in about 24 hours, without the escape of ammonia, free or combined (Gladstone and Tribe, *Jour. Chem. Soc.*, 1878, Vol. XXXIII., p. 150).

According to Divers, dry nitrate of ammonia condenses gaseous ammonia and becomes liquid. The liquid ammoniated ammonia nitrate is a good conductor and electrolyte—ammoniacal hydrogen appearing at the cathode, and nitrogen and ammonia nitrate at the anode. Anodes of silver, copper, lead, zinc, and magnesium are dissolved as ammoniated nitrates. An anode of mercury becomes coated with an almost insoluble compound. When the anode is acted upon the evolution of nitrogen does not occur (Watts's "Dictionary of Chemistry," Vol. VII., p. 860. *Chem. News*, Vol. XXVII., p. 37. *Proc. Roy. Soc.*, Vol. XXI., p. 109). Faraday electrolysed fused nitrate of ammonium. Hydrogen gas, mixed with a little nitrogen, was evolved at the cathode. The aqueous solution of the salt similarly treated yielded the same mixture at the cathode and oxygen at the anode.

Electrolysis of Ammonium Fluoride.—H_4NF. Molecular weight = 37. I electrolysed this salt in a state of gentle fusion by means of a current from six Grove cells, a platinum wire anode, and a platinum sheet cathode. Conduction was copious and heat was set free. Much gas appeared at the anode, but no odour of ozone.

Electrolysis of Ammonia Chloride.—NH_4CL. Molecular weight = 53·5. Hisinger and Berzelius by electrolysing with silver electrodes a solution of this salt observed that oxygen was evolved at the anode and hydrogen at the cathode, and the anode became coated with argentic chloride.

Electrolysis of Ammonic Carbonate.—According to Seebeck, a moistened cup of this salt filled with mercury yields by electrolysis with the mercury as the cathode the ammoniacal amalgam. E. Drechsel electrolysed a solution of ordinary commercial ammonic carbonate, by passing a continually reversed current through it by means of platinum electrodes during eight hours. On evaporating the resulting liquid a salt was obtained crystallising in fine white needles, and containing 64·69 per cent. of platinum. About 0·1 grain of platinum was dissolved in 10 hours by the ammonium carbonate. By working the commutator more slowly the temperature of the liquid rose, and by simultaneously cooling a crystalline precipitate occurred, containing 38·6 per cent. of platinum, and was also a salt of a platinum base (*Jour. Chem. Soc.*, Vol. XXXVIII., 1880, p. 300). B. Gerdes also electrolysed a solution of ammonium carbonate by continually reversed currents from 4 to 6 Grove's cells and platinum electrodes. He obtained besides ammonium nitrite and nitrate, urea, a fatty substance, and a soluble salt of platinum (*Jour. Chem. Soc.*, Vol. XLIV., p. 27).

Electrolysis of Sulphate of Ammonium.—Am_2SO_4. Molecular weight = 132. A solution of ammonic sulphate is decomposed by the current, acid and oxygen appearing at the anode, alkali and hydrogen at the cathode (Sir H. Davy).

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With iron wire electrodes, hydrogen and free ammonia appear at the cathode, and at the anode oxygen is evolved, but not until after some time; persulphate of iron also appears (Hisinger and Berzelius).

(CONCLUDED.)

Erratum.—Equivalent of Boron $\frac{10\cdot9}{3} = 3\cdot63$.

ELECTRICITY AND LIGHT.—IV.

BY JOHN T. SPRAGUE.

(CONTINUED FROM PAGE 136.)

31. *Light is one of the forms of radiant energy transmitted by undulations*, and in its capacity for moving in distinct straight lines or *rays* appears to be different from such a radiant transmission as that of sound. It is owing to this linear transmission that shadows are produced by light; if we take a cone of rays issuing from any luminous point, or a beam of the solar light the rays of which are parallel because of their vast distance from the luminous centre, and we interpose a screen in the path of the rays, a distinct portion is cut clearly off, and we have darkness behind the screen.

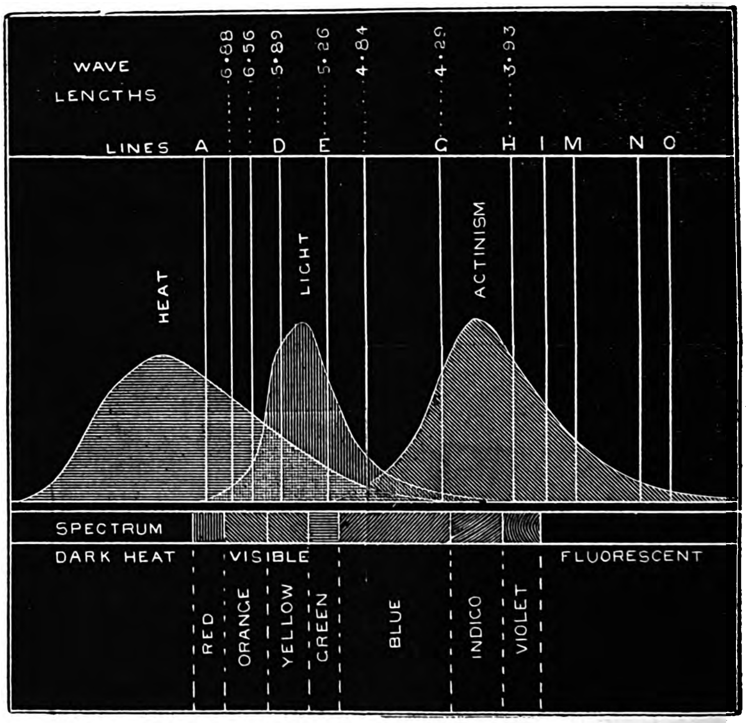
32. *Sound cannot be so cut off*, though its intensity may be diminished. The distinction of the two cases is to be found in the fact that sound turns round corners and light does not; this is at least the apparent distinction. A little thorough examination will prove that it is only apparent, and we can trace out the actual facts through the same illustrations as have already served to explain the various transmissions of energy. If we revert to the conception of Section 17, as developing the linear transmission of energy along a row of billiard balls into a spreading action, we may see that each point of an advancing ray constitutes a fresh radiant point or centre of energy, limited in the direction of its action by that of the surrounding rays, which, constituting the so-called *equipotential* shells, compel the united stream of energy to advance equally in all directions from the centre, and while apparently moving in true radial lines from that centre yet fill all the space they reach and charge every particle of the transmitting agency within that space.

33. The radial lines and the equipotential shells have in fact no true existence. They are produced, not at the apparent centre of action but at each point of the space itself, by the energy transmitted from point to point in the directions of least resistance at each point. The case is identical with the law of transmission of pressure in a liquid, which is equal in all directions, no matter what direction the cause of the pressure acts from. Thus water under pressure turns round any obstacle; *but that obstacle does produce an influence, and is an obstruction.* Thus water flowing through pipes is reduced in quantity by any sharp bends, or by a screen crossing the pipe, although the area available for the stream is not diminished, by a corresponding space being provided beyond the edge of the screen. Now it is evident that behind this screen, where an eddy of water forms, there must be a space in which no stream of water exists; in fact, this screen produces what we may call a *water shadow.* Behind it the lines of pressure of transmitted energy are cut off.

34. *The same effect occurs with sound;* but neither with water nor sound is there complete cut off such as we see with light. The energy presses in all directions and turns round the corners, setting up action behind the screen. But the same thing occurs with light, though not so obviously; it can, however, be traced out by means of the interference of the diffraction lines referred to in Section 29.

35. If we pass a beam of light into a darkened room so as to avoid the effects of diffused light, and interpose an opaque screen to cut off part of the beam and to cast a shadow upon a white screen, we shall find that the line of the shadow edge is not an absolute passing from darkness to equal light. We find it consists of a succession of spaces of greater and less illumination, one set of such fringes extending beyond the true line of the shadow into the light, while another but weaker set occupy a space within the true shadow. The light has thus been subjected to a bending action at the intercepting edge. So evident is this, that if a circular screen is employed, by regulating the dimensions and distances, we may obtain a shadow with a spot of light in its middle, surrounded with a series of dark and lighter circles. These are due to the interferences of the bent rays, which, coming from opposite sides of the circumference, have different distances to travel, and so at spaces corresponding to different wave lengths the two rays reinforce and neutralise each other, while their mutual effect is that of a feeble light thrown upon the true shadow of the screen.

36. *The great rapidity of the motion of light is the cause of the smallness of the quantity of the diffusion.* It is well known that a sheet of thin glass can be perforated by a very sharp and concentrated blow, as by a pistol bullet; in like manner a plank may be perforated by a tallow candle shot at it. With slower motion quite different results occur. On the same principles we can trace effects of deflection of rays of energy through the streams of water, sound, and light as related to the



Spectrum of Radiant Energy.

rapidity of the streams; and in comparing those of sound and light, as related to the wave lengths of the several undulations, which may be roughly averaged as 50in. for sound and 1-50000th of an inch for light.

37. The accompanying diagram represents the analysis of radiant energy as effected by the prism, and as partially manifested in the rainbow. This shows at once that what we call "light" is not a simple entity, but a complex agency, the component parts of which are capable of separation. The first rough separation appears to divide radiant energy into three agencies, or so-called "forces," exhibited by three shaded curves of heat, light, and actinism, or chemical action. The light again appears to be divided into seven parts, distinguished as *colours*, which were at one time supposed to be due to the overlapping of three primary colours; and even yet artists frequently dispute as to whether these three primaries are red, yellow, and blue, as at first supposed, or red, green, and violet.

38. The real truth is that each separate vertical line or section of the spectrum indicates the existence of a distinct agent, each slightly differentiated from its neighbour, and all forming a complete series. The beam of light as it enters and leaves

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the prism is subjected to a bending action, and the extent of this bending is dependent upon the angle at which the beam crosses the dividing line or surfaces, and the separating power of the prism is dependent on the several wave lengths of the many undulations which compose white light or radiant energy; it simply distributes these distinct undulations in a graduated order of wave lengths.

39. *The spectrum is therefore comparable with the wires of a piano.* Each wire has its own specific rate of undulation, perceived by the ear as a musical note; each line crossing the spectrum has in like manner its own specific rate of undulation and wave-length. *In space, and in the act of transmission, it has no other property,* but it becomes heat, light, or actinism, according to its relations to the object which receives it. Precisely the same occurs with the undulations of sound, which (Section 25) may also be perceived by the sense of touch as a succession of blows. The undulations falling upon the eye produce a sensation which analyses its properties, and light only exists in this sensation and perception. The same ray received upon inert matter sets up certain motions in it, which are *heat;* or the same ray received on some forms of compound matter sets up chemical decompositions. Therefore the three curves shown do not represent distinct forces but the different actions each ray can produce. As a consequence, the curves themselves relate only to particular modes of reception. The normal eye sees the seven graded colours, but it is very doubtful if any two see them exactly alike, and we know that many people are incapable of distinguishing some of the colours. The chemical action also varies greatly with different substances, upon which fact the various photographic processes depend. The actual curve shown is that of the combination of hydrogen and chlorine.

40. The lines shown crossing the spectrum give us the most perfect evidence of these principles. They represent certain dark lines which are found in the solar spectrum, and which are also obtained as distinct bright lines when the light of gaseous flames containing known substances is examined. They are the foundation of spectrum analysis, and as they can be obtained separately they enable their own separate wave length to be measured, as given in 10 millionths of a millimetre in the diagram. This measurement is effected by means of the coloured rings produced when a lens of small curvature is placed upon a flat plate of glass, and still better by the interference lines of light and shade (Section 29), which can be obtained by aid of two mirrors not exactly in the same plane.

41. Solid substances give a complete spectrum corresponding to the conditions, and the conditions depend upon the temperature to which the substance is raised; gaseous substances give only their own specific wave lengths or coloured rays. Thus the line marked D in the yellow is the line of sodium, and is seen when the light of a spirit lamp in which salt is vaporised is passed through a prism. Nothing should be then seen but this bright yellow line, which is really a double one with a dark space in its middle. In the actual experiment there is also a very faint continuous spectrum to be seen, due to the presence of some solid particles in the flame; but this does not affect the conclusions to be drawn from the existence of these constant definite lines accompanying particular substances.

A PHENOMENON IN MAGNETO-ELECTRIC INDUCTION.*

BY C. VERNON BOYS.

This paper dealt with impulses to which conductive bodies are subject when suspended in a magnetic field which suddenly or rapidly varies in strength. A disc of metal hung in a uniform field experiences, when the strength of the field is changed, a twisting force, tending to diminish the angle, and which its plane makes with the lines of force during an increase in the field, and to increase that angle during a diminution of the field. A ring of radius r, sectional area s, specific resistance ρ, at an angle a to lines of force, experiences a couple during a change in the strength of the field $H = -\frac{\pi r^3 S H \sin 2a}{4\rho}\frac{dH}{dt}$. When the field changes from O to H the impulse $= -\frac{\pi r^3 S H^2 \sin 2a}{8\rho}$. If the moment of inertia = M and the value of the torsion of the supporting wire = T, the throw of the ring when the field vanishes will be $= \frac{\pi r^3 S H^2 \sin 2a}{8\rho\sqrt{MT}}$. Corresponding expressions for discs and coils were given. One curious result is that whatever size or thickness (small) a disc of any given material may be, the angular velocity imparted to it during a given change of field intensity is the same.

Discs or coils suspended by torsionless silk threads in a field experience—when that field grows from zero rapidly—throws which depend only on the initial position. The throw is independent of the strength of the field, of the conductivity, or of the moment of inertia of the coil. The time occupied only depends on these things.

In a variable field a disc of metal tends to move to weaker parts during an increase, and to stronger parts during a diminution of field. This effect is so violent in impure copper, which is magnetic, that it appears strongly dia-magnetic.

The results of several experiments were given, which confirmed the formulæ. There was, however, a difference in the strength of a series of fields measured by the new method, and by the deflection of a coil, each in absolute units, which makes further experiments desirable. The method has advantages in point of simplicity and convenience for measuring the electrical resistances of metal in the form of sheets, and for measuring strong magnetic fields.

* Abstract of paper read by him before Physical Society, June 30, 1884.

PATENTS FOR REGULATING ELECTRIC CURRENTS.

BY C. A. STEPHENSON.

It becomes at the very outset necessary for me to wander away from a strict adherence to my subject; but I have to do so in order to lead up to the earlier patents for regulation, which were for automatically regulating the speed of a steam engine driving dynamo machines by means of apparatus actuated by the current produced by the dynamos.

These regulators aim at reducing the speed of the engine as the intensity of the current is increased by the resistance of the circuit being lessened, and are but developments of a still older idea of controlling marine and other engines by electro-magnetic appliances actuated by battery power. It is obvious that very much the same mechanism which was used to set a battery in circuit could be adapted for utilising the current of a dynamo for similar purposes.

In the first patents, therefore, to which I shall call attention, a current of electricity is used for controlling an engine, which itself has no connection with any dynamo or electric current-producing machine.

With these preliminary remarks, I shall now proceed to the question of

Controlling Steam Engines.

The first patent to be noticed was taken out by Mr. Walker Moseley, No. 3802, of 1872. The prime object of this patent is the controlling of marine engines by utilising the motion of the ship for closing the circuit of a battery current. The drawings and details of the specification refer almost exclusively to marine engines, and it would therefore be of little use to reproduce them here. What is material to the present question is that the inventor states that the governor can be actuated by a rotary motion instead of the ship's motion, and could thus be used for controlling land engines; with this view he claims "the use of electro-magnetism for shutting off steam in a land engine when any given abnormal or improper movement of the same takes place." The claim is a very wide one, but as the patent is void it is only as a publication that it has interest. Taking the specification and the claim together they describe the use of electro-magnetism for controlling the speed of an engine by more or less opening or closing the throttle valve.

The next patent bearing in any way on the point is that of Mr. A. M. Clark, No. 2648, of 1874. This patent requires but a cursory notice. It is described as an electro-magnetic governor for steam heating and drying apparatus, "and comprises an engine for working a cut-off valve and a throttle valve of steam-heating apparatus, with automatic apparatus for opening and closing the valves . . . . the apparatus being controlled by electric currents closed and broken by variations of heat through the medium of thermometers in a heated room." This patent is also void.

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In 1875 Mr. C. C. Walcott took out a preliminary specification, No. 3789, for controlling a marine engine by means of electro-magnetism. In this specification the electric current is used "to control the force exerted for operating the throttle valve of the engine."

In the foregoing patents electricity was utilised as a means of controlling steam engines. The electric currents being produced by batteries were in no way dependent on the engine, but in the patents I am now about to mention a new order of things was introduced.

An electric current is produced by a dynamo driven by a steam engine, and it is attempted to regulate the current by causing it to control the speed of the steam engine through the medium of an electro-magnetic controller. The first patent of this sort was taken out by Mr. St. George Lane-Fox, No. 3988, of 1878. I will describe it in Mr. Fox's own words:—

"In my regulator I make use of what is known as the quadrant electrometer. In this instrument the position of the suspended

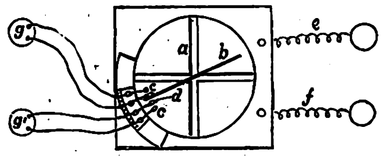

Fig. 1.—Lane-Fox's Electro-Magnetic Regulator.

needle will depend on the relative electromotive force of the so-called quadrants. By connecting this instrument with the main and the earth in the ordinary way, the electromotive force of the main will determine the position of the suspended needle. If it increase or decrease, the position of the needle will be altered accordingly. Now, I fit this electrometer with small pegs, so that a slight deviation of the needle one way or the other will bring it in contact with one of the pegs, and thus complete a circuit, and set up the electric current, which, acting on an electro-magnet, sets a lever or other suitable device in action. The contact with each peg forms a separate circuit, acting independently on two of these levers or other devices, which are in connection with steam valves, one diminishing, the other increasing the supply of steam to the engine which works the electric generators.

"Fig. 1 represents a quadrant electrometer adapted to regulating the electromotive force in the mains as just described; *a a* are the quadrants, *b* the suspended needle, *c c* the pegs of platinum or other suitable material, *d d* are springs situated between the needle *b* and the pegs, *e* is the wire connecting the main, *f* is the wire connecting the earth, $g\ g^1$ are electro-magnets in connection with their respective pegs $c\ c^1$. These magnets act on levers or other devices for operating the steam valves."

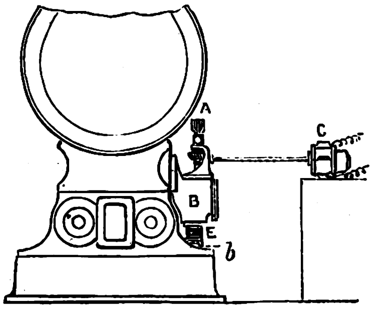

Fig. 2.—Richardson's Electric Governor for Engines.

The foregoing portion of this patent was entirely disclaimed in the second disclaimer to the patent taken out by the Anglo-American Brush Electric Light Corporation on July 30, 1883. The practical effect of this is the same as if all the above was a void patent.

No improvements in this mode of regulation were made for nearly three years, when Mr. John Richardson, of the firm of Messrs. Robey and Co., filed a specification, No. 288, of 1881.

The object of this invention is to regulate to an absolute uniformity the speed of engines employed for driving dynamo machines. To achieve this, in Mr. Richardson's words, "I mount upon the governor itself a small dynamo electric machine, which is actuated by the same current as that which produces the light." A little further on he refers to the dynamo as a motor, and there can be very little doubt that it is his intention to drive the governor of the engine from a motor, the motor being "actuated by a portion of the main current which produces the electric light, and its speed varies in relation to the intensity of the said current, so that when the large dynamo machine which produces the current has reached such a speed as gives the required intensity the governors at the same time attain sufficient speed to shut off all further admission of steam, and the current is therefore retained exactly at this intensity."

Fig. 2 shows an elevation of a Robey engine fitted with the governor.

A is a high speed governor, acting directly upon an equilibrium valve contained within the chest B; C is the motor.

Let it be presumed that the governor acts as described, and that the current in the circuit is kept constant. The infallible law of Ohm's $c = \frac{E}{R}$ will cause the electromotive force to vary inversely with the resistance, so that with every change of resistance in the circuit the electromotive force will vary. Mr. Richardson's conclusion that it is evident that the governing will be perfect will hardly be generally accepted.

In the same year, 1881, Mr. Carus-Wilson took out a patent, No. 5687. The object of this invention is to supplement the action of the governor of an engine so that it shall be made to regulate the cut off with respect to the electromotive force produced.

The revolving governor is acted on by a weight; the weight is controlled by electro-magnets, which are brought into action by currents whose circuits are made or broken by a galvanometer needle.

A reference to Fig. 3 will show clearly how it is proposed to carry this into effect:—*a* is the shaft on which the governor rotates; *b* is part of the rotating gear of the governor, which rises with the increase of speed; *c* is a weight resting on *b* which rises and falls with the governor; *d* is a lever with a fulcrum at *e*, of which the end *f* is forked, and fits into a groove in *c*, so that *c* can turn round and move *d* up and down; $g^1\ g^2$ are two solenoids fixed on a frame *h*, with a common core *j*. *j* is held by a fork, *k*, at the end of *d*; *l* is a spring fixed to *d* and *h*, and capable of being ad-

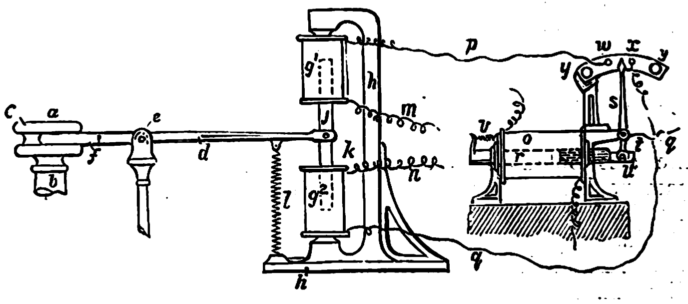

Fig. 3.—Carus-Wilson's Electric Governor for Engines.

justed; the ends *m n* of the solenoids $g^1\ g^2$ are joined together and go to the negative cable of the machine; *o* is another solenoid, with a core, *r*, which extends right through and rides in bearings at each end; the shaded portion is iron; *s* is a pointer pivoted at *t*, and working on a pin, *u*, fixed on *r*; *v* is an adjustable spiral spring; *w x* are two stops of metal, to which are joined the wires *p q*. The wire of the solenoid *o* is in direct circuit between the positive and negative cables; the pointer *s* is of metal and is connected to the positive cable. *v* is adjusted so that at any desired electromotive force the pointer is between the two stops *w x*; *l* is also adjusted so that the weight *c* is raised sufficiently off the governor to allow the engine to attain its proper speed. If for any reason the electromotive force exceeds the proper amount the core *r* is drawn in, *s* touches *x* and makes a circuit between the positive and negative through the solenoid g^2 hence *c* gets lifted, the governor rises, and the speed is diminished.

If, however, the electromotive force falls the converse action takes place, *s* makes a circuit with *w*, and the speed of the engine is increased; *y y* are two screws with milled heads for regulating the position of the stops *w* and *x*.

The apparatus is made more or less sensitive by placing the stops *w* and *x* nearer or further from each other; but in any case they should be equidistant from the pointer when in its adjusted position.

The apparatus is somewhat complicated, but Mr. Carus-Wilson explains that it can be simplified by making the core *j* a natural magnet, with a north pole just inside the bobbins g^1, the south pole being just inside the bobbin g^2. The bobbins are wound so that their south poles are opposite each other; *l* is adjusted so as to allow the engine to attain its proper speed; *m* and *n* are joined to the negative, and *p* and *q* to the positive conductor. The whole apparatus lettered *r* to *y* is thus discarded. In this modified arrangement any increase or decrease of electromotive force acts on the governor in the same way as heretofore, but there is a constant current flowing through the coils of the solenoids, the automatic arrangement for making and breaking being entirely discarded.

In the same specification Mr. Carus-Wilson shows "a further development of this principle."

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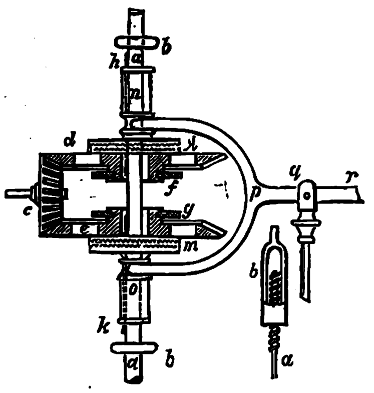
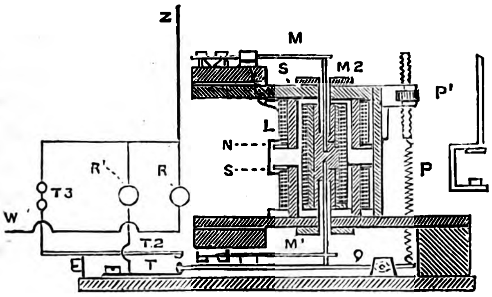
In order to understand the further development a reference must be made to Figs. 4 and 5. In Fig. 4 *a* is one of the rods connecting the governor with the valve gear; *a* moves in bearings at *b b* up and down with the governor, *c d e* are three toothed wheels, *d* and *e*, being driven by *c*; all work in fixed bearings; *d* and *e* move in bearings *f g*. The centres of *f g* are large enough to let pass the rod *a* with keys at *h* and *k*. *d* and *e* carry small collars, *l* and *m*, respectively, each having a row of teeth. Two pieces, *n* and *o*, ride on *a*, and have slots inside to take the keys *h* and k, so that *a* moves freely up and down, but is turned round if *n* or *o* turn round. *p* is a fork at the end of a lever, *r*, pivoted at *q*, and sustains *n* and *o*, so that the rows of teeth on *n* and *o* are just clear of those on *d* and *e*. At the other end of *r* is the arrangement of two solenoids, &c., as shown in Fig. 3. In fact, *r*, in Fig. 4, corresponds to *d* in Fig. 3. *c*, Fig. 4, is turned by being connected to part of the moving gear of the engine.



FIGS. 4 and 5.—Further development of Carus-Wilson's Electric Governor.

Above and below the bearings *b b*, Fig. 4, are connections, as shown in Fig. 5. *a* in Fig. 5 is the shaft *a* of Fig. 4; *b* is a stirrup-shaped piece cut to take the screw on *a*. The other end of *b*, Fig. 5, forms a continuation of the gear between the valve and the governor, and there is an apparatus below similar to *b*, except that the screw is cut the other way.

Now, upon an increase or decrease of electromotive force one or other of the coils g^1 or g^2, Fig. 3, is brought into play as before described, and the top or bottom teeth, Fig. 4, clamp in those opposed to them, the result being that *a* is turned round one way or the other, and the two pieces *b*, Fig. 5, above and below are separated or drawn together, and the necessary regulation is effected at the throttle valve or expansion gear. The governor normally regulates the engine, but its action is supplemented if the electromotive force varies. Simplicity cannot be claimed as a merit for any of the above apparatus. The adjustments of the springs *l* and *v* in Fig. 3 must require the greatest nicety. The whole apparatus appears to be of too delicate a nature for the purpose required. The combinations, however, have the merit of novelty.



FIGS. 6 and 7.—Varley's Regulator.

No further specifications for regulating by controlling steam engines was filed to the end of 1882. This, therefore, completes the list of those under review. Before, however, quitting this portion of the subject of regulation, I must mention a patent of Mr. Varley's, No. 5665, of 1881. Mr. Varley claims for it "the use for controlling the speed of a motor employed to produce electric light," &c. In the patents hitherto mentioned the regulation was confined to governing steam engines. Mr. Varley's regulator, however, is intended to be used not only with steam engines, but with any motor, and would come under a more general heading of

Controlling Motors.

Fig. 6 shows the construction of what Mr. Varley calls the regulator magnets.

L is an electro-magnet, the poles of which, N and S, are tubular, and approach each other in the centre; M and M^1 are equilibrium springs; M^2 and M^3 are conductors, against which the equilibrium springs press; M^2 is attached to, but insulated from, the soft iron cylinder O; M^3 is in electrical connection with the soft iron cylinder; P is an adjusting spring attached to the end of the pivoted lever Q, which rests on a hook at the lower end of M^3, shown separately in another position in Fig. 7; P^1 is a screw nut, by means of which the required amount of strain on the cylinder O can be adjusted.

When this apparatus is in circuit the current passes through the conducting wire W, and divides itself through the electro-magnet L and the resistance shunt R on to the electric lamps Z; part passes through the insulated wire of the electro-magnet L, and through the spring M, to the conductor M^2, and thence to the insulated wire surrounding the soft iron cylinder O; from this the current proceeds *viâ* the metal of the soft iron cylinder through conductors M^3 and lever Q on to the contact spring T and through R^1 to the lamps Z. When the electricity developed exceeds the desired amount the soft iron cylinder O is raised, and the lever Q closes the circuit through the contact spring T^2. This spring T^2 is connected with the electric governor T^3, details of which are given in Fig. 8.

It is not clear from the context how the action of raising the soft iron cylinder is brought about. All that can be gathered from the specification is that the regulator magnet L has tubular extensions, with poles directed towards one another and approaching within a short distance. The soft iron cylinder O is mounted in these tubular extensions, and is there held in a state of equilibrium by springs M M^1 pressing in opposite directions. This explanation by no means makes the matter clear. I may add that I have taken the whole of the foregoing description nearly word for word from the specification.

But to return to the electric governor shown in Fig. 8. X is the revolving shaft of the motor, which communicates through the pawl and ratchet X^1 to the centrifugal governor levers. Y Y^1 are

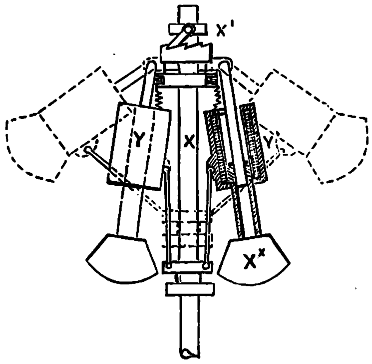


FIG. 8.—Varley's Electric Governor.

the tubular balls of the said levers. Y^1 is shown in section. When the circuit is closed through the helices of Y Y^1 the cores "become electro-magnets, and draw up the weights X^x as indicated by the dotted lines, thus cutting off the supply of actuating fluid from the prime mover (by closing the throttle valve)."

It is evident that when the weights X^x are drawn up the effect is "to reduce the diameter of the orbit through which the governor weights (balls) revolve, and by a well-known law it results that this rate of revolution becomes immediately increased, and consequently they travel round faster than the shaft which communicates motion to them. Thus the balls become raised by the centrifugal force, and the supply of actuating fluid to the motor is arrested by closing the throttle valve in the usual way."

No explanation is given of how the coils of Y Y^1 are brought into the circuit at T^3 (Fig. 6), but obviously there are many ways in which this could be done.

With regard to Figs. 6 and 7, the claim is for "the use for regulating electric currents of a soft iron cylinder, wrapped in two sections with insulated wire coiled in alternate directions, and mounted in a tubular electro-magnet in such wise that when the current exceeds a certain determined intensity the whole, or a portion of it, is diverted into a second circuit, substantially as and for the purpose described."

As regards the governor, the claim is for "the use for controlling the speed of a motor employed to produce electric light, or for other purposes, of a governor so constructed that the effective length of its arms can be altered when desired by the action of an electric current, substantially as described."

Both these claims appear to be novel, but whether such delicate apparatus is suitable for the purposes required of it practical experience alone can determine.

This brings to a close the section for apparatus for regulating by controlling steam engines and motors.

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CONTENTS.

Notes ... 217
Electro-Chemistry. By Dr. G. Gore. (Concluded) ... 222
Electricity and Light.—IV. By John T. Sprague. Illustrated ... 224
A Phenomena in Magneto-Electric Induction. By C. Vernon Boys ... 225
Patents for Regulating Electric Currents. By C. A. Stephenson. Illustrated ... 225
The Finance of Electric Lighting ... 228
Correspondence ... 229
The Health Exhibition ... 229
Dynamo-Electric Generators ... 231
Electrolysis of Sulphuric Acid in Accumulators ... 234
The Iridium Industry. By W. L. Dudley ... 234
Legal ... 236
The Direct United States Cable Company ... 236
Companies' Meetings—
Eastern Telegraph Company 236
United Telephone Company 239
Companies' Share List ... 240

LETTERS.

H. A.—*A letter awaits you.*

THE FINANCE OF ELECTRIC LIGHTING.

The contrast between the financial prospects and predictions of 1880-1 and the sober certainties of 1884 causes many of those who, in the earlier period, were full of confidence, to speak with mournful assurance of the "collapse of electric lighting." In truth, however, not only has there been no collapse, but there has been a steady and perceptible progress of invention and improvement. That which has collapsed are the avaricious fancies of those investors who allowed themselves to be misled by the glitter and unreality of representations that can only be characterised as fraudulent. So eager was the search for a good investment; and so robust was the faith in what was airily termed "electricity," that any one with a specification for lamp or dynamo found little difficulty in exchanging paper patents for hard cash. Now we have awoke out of sleep, it is the public who have acquired the experience and the promoter the money.

The concession of rights or franchises to supply cities and villages within a certain area with current on demand and at fixed prices was competed for helter-skelter by some of the shrewdest heads in the city of London. No one waited to inquire whether this thing, which was to revolutionise the conditions of life, was or was not feasible and financially profitable. It was assumed that the problem was solved, and the public backed its assumption to the tune of eight millions sterling. The actual state reached by electric illumination was recorded in the history of a couple of exhibitions, in which each exhibit was jealously watched by an army of trained supervisors, and by the achievement of a little public and private lighting, accomplished for the most part at a heavy loss to the the undertakers. Of further actual experience there was none. The daily press fostered the illusion, capital was got together, and so ended the first act of the comedy.

Expert witnesses, lawyers, promoters, accountants, directors, and patent agents were feed on a lordly scale. The workman who could turn up a commutator or could set brushes was paid his own price; but the outflow of money in those channels was found insufficient. "Free exhibitions" and installations at a loss furnished the vent which was needed, and those with rentals at the "price of gas"—whatever that may mean—contributed to the collapse of which we have spoken. But all is not yet lost. There are still some three million pounds uncalled from the shareholders. If the real business of profit earning is set about with open eyes and level heads it is still possible "*tout peut se retablir.*"

We have already dwelt on the legislative restrictions which obstruct the financial development of electric lighting. The letters from Mr. Arnold White and Dr. Fleming which appeared in a recent issue of *The Electrician* are unanswered, and, in our judgment, are unanswerable. But if the Act were repealed, and a measure substituted for it wisely conceived in the interests of progress, while protecting the rights of property, we cannot shut our eyes to the fact that we should be little nearer the desired end if other reforms of a more administrative character were deferred or neglected. The extended scale on which the companies were laid down is better fitted for grappling with the business of a State Department than the languishing operations of a retail trade. Rent of offices and works, directors' fees, and remuneration to staff for the most part were calculated on a turnover of capital which has failed to appear. Unless, therefore, legislative assistance is supplemented by a vigorous use of the pruning knife and an improved administration, no fact in physics is more certain than that the capital yet uncalled will follow the millions which have gone before.

There are in the directorate of the various companies individuals who would not only adorn, but would guarantee the success of any undertaking with which they were connected. On the other hand there are influences which—to speak with moderation—we can only regard with limited enthusiasm. Directors who are connected with a round dozen of companies cannot be expected to give that individual support, or make the resolute efforts without which no enterprise of so complicated and wide a scope as this can hope to succeed. The fact of a man undertaking the trusteeship of proprietors' interests in ten or a dozen companies at one time is a measure of the small importance he attaches to the performance of such duties. His efforts are diluted. "He spreads himself," as the Americans say, "too thin." When Stephenson was building the line to Birmingham he walked fifty-three times between London and the Midlands. Unless some such spirit as that of Stephenson animates those driving the coach, we may call until we are hoarse for a Board of Trade Hercules to pull our wheels out of the mud.

To sum up, electric lighting must be cheapened by a reduction in the permanent charges, *i.e.*, directors' fees, rent, and the cost of official staff. The administration must be seriously

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undertaken by men who rate the difficulty of their task too highly to suppose that odds and ends of time are sufficient in which to accomplish the end in view. Too great stress cannot be laid on the fact that management which would ruin a butterman is not likely to organise victory for electric lighting. It is said that whatever money has been scraped together has been made up four pairs of stairs. Elevation of principle may not perhaps lead so high as this, but a new spirit of wise economy must permeate every department of electric lighting, or the champagne and glitter of the exhibitions will be the only things the country will remember of this effort to replace the existing method of artificial illumination.

CORRESPONDENCE.

ELECTRIC LIGHTING ACT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 5th inst. you invite expressions of opinion from your correspondents on this subject, but you have already so fully brought under notice the various points that there is little left to be said. Without doubt the interference on the part of the Board of Trade has resulted in almost total ruin of electric lighting. In no way can the Act be called anything else than a gas protection Act, and it has proved itself to be utterly restrictive to electric lighting. But now that this has been demonstrated, should there not at once be an agitation got up for the purpose of having it forthwith removed from the Statute Book? Why should not the electric light companies and those connected with electrical engineering unite together and form some sort of a protective society whose aim should be the repeal of the Act and the promotion of the welfare of electric lighting? And in this connection permit me to point out that although we may blame the Act for preventing the formation of central lighting stations for the lighting of shops, &c., yet what reason has prevented the adoption of the light in mills and other works? Nothing but its enormous cost. Although these places are provided with engine power, attendance, and afford every advantage for the working of the lights, we are prevented from lighting them owing to the exorbitant cost compared with gas. Had the directors of the different electric light companies who have had to go into liquidation been more energetic in getting the prices of the apparatus reduced to a reasonable figure, I venture to say that many of these companies would have been in a satisfactory working condition at the present day. To those who, like myself, have given up good situations to join electric lighting companies, it has been vexing to see so many opportunities thrown away. In this district alone thousands of lamps might have been working, and had these installations been carried out, it would have been the best evidence we could produce in approaching Parliament to show that the Electric Lighting Act is far too severe for any company to undertake the erection of central lighting stations on the terms required by that Act. I might give you the details of the provisional order granted for Dundee; but I am of opinion we all know the ridiculous terms of these orders too well, and that we have already given them more than enough of criticism. Our best plan now is to take action to get the Electric Lighting Act modified, and the prices of the apparatus reduced to a fair sum, so that we may be in a position to carry on an extensive business in mill lighting this ensuing winter, while our position may be under consideration by the Legislature.—Yours, &c., W. C. MARTIN.

Commercial-street, Dundee.

DYNAMOMETERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On Friday last, while looking through a note book belonging to Mr. Conrad Cooke, the last entry having been made in 1863, I came across a sketch of precisely the same arrangement as that described on page 202. Mr. Conrad Cooke cannot recall the source from which the sketch was taken, but I imagine the plan cannot be well known, as Mr. Kapp had not met with it in his researches on the subject of his very interesting communications.—Yours, &c., ALEX. P. TROTTER.

7, Furnival's Inn, E.C., July 15, 1884.

THE HEALTH EXHIBITION.—II.

The engineer decides that his governor must be very sensitive in order to comply with the demands of the electrician, and next to obtaining a governor that will act in advance, or simultaneously with the change, he provides one that acts almost simultaneously, so quickly, in fact, that it needs a trained eye to detect any lapse of time between cause and action. Another demand upon the engineer is that his engines shall run, without stopping, for a long number of hours at a stretch. This is no new demand, for marine engines are called upon to run almost continuously, but hitherto, with this exception, hardly any engine has been called upon to work so continuously as electric-light engines. Still further, in order to obtain economy, the engines are not only called upon to run and give out, not a nominal horse-power, but frequently a power almost or quite to their full capacity. Comparisons are odious, that we know, and it will be found that some of our most eminent engine builders have failed to please electric-light engineers. It would be interesting, for example, to have full details of the experience of the Brighton Corporation with their engine at the Pavilion. Without attempting to detract from the merits of the ordinary make of engine, we may say—and we would say it most emphatically—that a too great laxity has been shown by our prominent engine makers in the matter of electric light engines. This class of engine needs a special design, while too frequently all that has been thought necessary has been to dub the ordinary engine "good for electric light purposes." A new departure may be chronicled with the Fisheries Exhibition. Engineers learnt something from that exhibition, and have greatly profited by the knowledge so gained. How far the requirements of electricians have been met in the "Healtheries" Exhibition we hope to be able to show. Leaving, however, for the moment the prime motor, we must turn our attention to the intermediate part of the apparatus, viz., the dynamo. The dynamo, like the pump, must be made to fulfil certain conditions. Let us suppose, for instance, that we have a reservoir of water, into which the water has to be pumped by a pump actuated by a steam engine. Further, suppose the water runs out of the reservoir through one very long and comparatively small pipe, with portions at intervals still smaller than portions representing lamps in the electrical pipe or circuit. Suppose, further, the water is required to run out in a constant volume. We see at once this can be done only by the pump pumping the water to a certain height. The pump to do this work would not be constructed similarly to one required when the reservoir was tapped by a considerable number of pipes, all of similar section, it may be, to the pipe above mentioned, and each pipe containing only one small section. The former pump would have to raise a small quantity of water to a higher level, while the latter would raise a large quantity to a lower level. Dynamos have to be designed to do work something after this manner, for lamps, and especially arc lamps, are sometimes arranged one after the other along the same wire, to the tune of 10, 20, and up to 40. The dynamos built to supply lamps arranged like this—as the electricians say arranged in series— have so to speak to raise a small quantity of electricity to a high level (high potential). The dynamos built to supply the lamps arranged upon the other system—called the parallel system—that is, upon a number of parallel or practically parallel wires, each carrying one lamp, have to raise a large quantity to a lower level.

In visiting the Healtheries we shall feel small if, before talking with those in charge of the electrical apparatus, we do not make ourselves pretty familiar with some of their pet tech-

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nical terms. Thus, to recapitulate, electricity which is analogous to water raised to a high level is said to be at a "high potential." Lamps put one after the other upon the same wire are said to be in "series;" most arc lamps are so placed. When the lamps are placed as in the diagram (Fig. 1) they are said to be in "parallel" or "multiple arc."

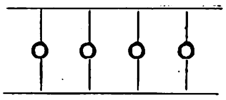

FIG. 1.

The dynamos to supply lamps in "series" are sometimes called "high tension" dynamos. An example of such a machine is the ordinary "Brush" dynamo. The dynamo to supply the parallel system is sometimes called a "low tension" or a "quantity" machine. An example will be found in the "Ferranti" or the "Edison" machine. Lamps are not always arranged so simply, but may be arranged in a combination of the two systems, and dynamos properly designed to supply such combination must be built. The Crompton-Bürgin dynamo may perhaps be cited as one used for such combinations. Thus far it has been attempted to show that the electrician in designing his dynamo must design it with a clear idea of certain work it has to do. He must, however, keep other ends in view besides the one we have so briefly discussed.

The wire which is employed to conduct the electricity—and which, in order to ease our explanation, we have looked upon as similar in the one case to the pipe used to convey the water in the other case—like the pipe, offers a resistance to the passage of the current. It is impossible with the most delicate of instruments to obtain indications of the phenomena called a current of electricity through some materials; in fact, some substances seem to be electricity proof, just as some are waterproof. Those substances which seem "electricity proof" are technically called "insulators." Thus resins, glass, gutta percha, india rubber, &c., are "insulators," though it may be well to say that it is doubtful if there is anything absolutely "electricity proof." Substances, on the other hand, which allow the phenomena of the "electric current" to be easily recognised are termed "conductors." Such are the metals, carbon, acidulated water, and so on. Some of these substances seem only to admit of the phenomena with difficulty—some seem to present hardly any opposition to the current. Silver and copper are among the substances that most easily admit the phenomena, and are therefore termed good "conductors," or substances having the least "resistance" to the current, while "carbon," "platinum," "iridium," "platinum-iridium," &c., offer great resistance, and hence are comparatively bad conductors. When the electrical current passes through a substance it, of course, heats it, and the heating power is some function of the resistance. The *same amount of current* per unit of time passing through a silver and a platinum wire of similar sections would make the platinum wire red or white hot, but would have no visible effect upon the silver wire.

The end we have in view is to show that the designer of dynamos must keep in view the "resistances" he has to deal with, some external to the machine, some internal. While this is the moral, a digression will be allowed in order to obtain familiarity with symbols and terms. Resistance, current, and potential have been mentioned. Difference of potential is called electromotive force. This latter is represented generally by E, the two former by R and C respectively. The relation between these was first determined by Ohm, and is therefore called Ohm's law, and is thus represented $C = \frac{E}{R}$, or $C\,R = E$, or $R = \frac{E}{C}$. No electrician can talk five minutes without referring several times to this law. The words italicised just now will be understood better by reference to the last formula, $R = \frac{E}{C}$. If R increases while C remains constant, then E must increase similarly to R; that is, if R is doubled, E must also be doubled, and so on. Using figures, $3 = \frac{6}{2}$, a fact understood by all who have mastered simple division. Here 3 is the quotient, 2 the division, and 6 the dividend. Keeping the division the same, and making the quotient 2×3, or 6, the dividend must become 2×6, or 12, in order that the answer may be correct, the whole being now written $6 = \frac{12}{2}$. The only figure remaining constant is 2. Now, E in electrical matters is analogous to the head of water, and if the head of water is constant while the section of the pipe varies, the current of water will vary; but if the current must be constant with a pipe of varying section the head of water must vary. A platinum wire of the same length and section as a silver wire has a much greater resistance, R. Therefore, if we take separately two similar pieces of these wires and attempt to send a current through them, we must, in the case of the platinum wire, have a current of greater electromotive force than with the silver wire if the current is to be the same in each case. Although at the risk of tiring some readers, we will attack this question in another way. Given two pipes—one connected to one cistern, the other to another cistern—the pipes being of the same material, length of section, and similarly placed in all respects, except that one pipe is partly filled with sand. The same quantity of water is wanted per minute from each pipe. It will at once be seen that the water in the cistern connected with the pipe partly filled with sand must stand higher than in the other, in order that the head of water may counteract the extra resistance to the passage of water given by the sand. So electricity must be at a higher potential, that is, have a greater electromotive force, when an equal current is required through a substance of greater resistance. If this verbiage has not helped to make the matter of how current depends upon electromotive force and resistance clear, we hope readers will turn to an elementary book on the subject, and continue the study till light is thrown fully upon the question, for, till it be comprehended, little real knowledge can be obtained about electrical apparatus. The electrician has to design his dynamo for the work it is to do. Suppose, then, it is to supply 20 lamps in series, and that the resistance of each lamp is represented by 10. As these resistances come one after the other, the total resistance will be the sum of the separate resistances (we put aside for the moment the connecting wires), or will be represented by $20 \times 10 = 200$. If the current required be 10 he must design a machine to give an electromotive force

$$E = CR = 200 \times 10 = 2{,}000.$$

The electrician will not give bare numbers like these, because he has a name for his units of current, &c. Thus, the unit of electromotive force is called a volt; of current, an ampere; of resistance, an ohm; and the above would be stated. A dynamo to give a current of 10 amperes through a resistance of 200 ohms must give the current with an electromotive force of 2,000 volts.

Looking at a dynamo, two binding screws will be seen, to which the ends of the external wire, or the wire carrying the lamps, are fixed. These are called the terminals of the machine, and it is the difference of potential between these two points that gives the electromotive force. The electricity, comparing it again with water, is as it were piled to a great height at the one terminal, called the + or positive terminal, while the − or negative terminal represent the low points, similar to the low level to which the water runs. Representing the high potential by P, and the low by P^1, then $P - P^1 = E$. When talking about water, the level of the sea is accepted as a datum line; and if a head of water is 100ft. above this, and connected by a pipe to a piston 100ft. below it, the pressure upon the piston is that due to 200ft. of water. The datum potential adopted by electricians is the potential of the earth; but when we deal with dynamos, the potential at the − terminal is generally as much below the zero potential as that at the + terminal is above it. Thus, to get $E = 2{,}000$, the designer would so arrange matters that $P = 1{,}000$ and $P^1 = -1{,}000$, so that $P - P^1 = 2{,}000$.

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DYNAMO-ELECTRIC GENERATORS.

We have received from America the report of Mr. Sprague, of the United States Navy, on the Electrical Exhibition at the Crystal Palace. This is hardly the place to ask why we are indebted to America for this admirable report. We are glad that someone has performed the work our own Government or the authorities of the Crystal Palace should have performed. Professor Adams, in his inaugural address to the Society of Telegraph Engineers, gave an excellent abstract of this report, but was of course compelled to pass over without much notice some parts of it. We have thought that some extracts, supplementary to Professor Adams's paper, will prove interesting to our readers. Thus:—The Crystal Palace Electrical Exhibition was the second of a series which is likely to embrace exhibitions in most of the great commercial centres. Following close upon that of 1881 in Paris, it did not promise, in its early stages, to be very successful, either as a commercial enterprise, or as a scientific exhibition of new discoveries and important progress. Despite the activity of invention, it seemed improbable that any great advance had been made in the short time intervening between these exhibitions such as to warrant the organisation of the second. But the Paris Exhibition had served to make prominent that electric lighting was becoming a reality, a new branch of industry was proved successful, gas and the arc light had found a rival, and the great strides made in perfecting the incandescent lamp and developing a system for domestic lighting were awakening not only scientific but popular interest. The many evils attending the use of gas as an illuminant promised much for a means of lighting which would offer any advantages.

The arc light, after several years' trial, while fairly successful in some places, and under certain circumstances, has too many inherent defects to prove generally useful, and its displacement is only a matter of time. Two years ago Henry Draper said that he would not be surprised if we were on the eve of a great change in electric lighting; that the incandescent lamp would entirely take the place of the arc light.

Although this change has not yet come, it is, I think, certain to do so, and my reasons for so thinking will later be evident. It may be thought that on account of the present inequality of light economy between arc and incandescent lamps, an intermediate form, the semi-incandescent lamp, would be the more acceptable because of its steadiness and brilliancy, but in practice and theory certain disadvantages become apparent which negative this idea. The incandescent lamp thus becoming of such importance, any exhibition which would serve to awaken invention, stimulate healthy competition, and enlist public interest and capital would in the end prove successful, both in a scientific and commercial point of view, and such the exhibition at the Crystal Palace finally proved to be, despite the disadvantages of its origin. It was not designed solely for the purpose of electric lighting, especially in the domestic form of application, but was intended to embrace a great variety of inventions in all the different forms in which electricity could be made use of. These were embraced in the following classes:—

I. Static electricity.
II. Batteries and allied apparatus.
III. Magneto-electric and dynamo-electric machines.
IV. Cables, wires, conductors, and allied apparatus.
V. Apparatus for measuring electricity.
VI. Telegraphs, signals, and allied apparatus.
VII. Telephones, microphones, and photophones.
VIII. Electric lighting.
IX. Electric motors and transmission of energy.
X. Electro-medical apparatus.
XI. Electro-chemistry.
XII. Magnets, compasses, horology, instruments of precision, &c.
XIII. Miscellaneous.
XIV. Generators, steam, gas, and hydraulic engines, &c., applicable to electric industries.

Nearly three hundred exhibitors took part, each exhibiting in from one to seven classes. In several of the divisions there was an excellent collection, but in some others very little of importance. Especially so was this the case in Class IX., where there was no evidence of any material progress. This is to be regretted, because the transmission of energy is destined to play a part second only, if even that, to electric lighting. In fact, the two will often go hand in hand. Hence, as far as this exhibition is concerned, electric lighting, especially in the domestic form, was of the greatest interest and importance, and, in view of the necessary character of this report, I shall confine myself almost entirely to such part of the exhibition as relates to this subject. I shall not generally describe exhibits as a whole, but will consider the merits of individual machines, lamps, and systems, discuss the theory of the dynamo machine, investigate the demands of a system of electrical distribution, consider the application of the electric light to men-of-war, and describe our experimental work. And in so doing I shall take what I consider the most important examples.

History of the Dynamo-Electric Machine.

Let me briefly review the history of the development of machines for converting the energy of motion into that of electricity.

In 1831 Faraday, reasoning from the remarkable discoveries of Œrsted, Arago, Sturgeon, and Ampère, was led to make a series of experiments for the purpose of evolving electric currents by the mutual action of closed circuits and magnets, and in the latter part of the same year made public the theory of the "lines of force" or the magnetic field, which is now recognised as determining the action of all electric machines. Not only is the magnetic field present in the case of iron or steel, but it surrounds every conductor in which flows an electric current. Three years after the announcement of the theory of magneto-electric induction, no less important than the laws of electro magnetism which had preceded it, Lenz announced a law which may be enunciated as follows:—That the currents induced by the relative movements of closed circuits and magnets, or of two closed circuits, are always such as to produce mechanical forces tending to stop the motion which produces them.

Pixii was the first to make a practical machine embodying the principles set forth by Faraday. This was in 1832, when he brought out a machine in which he revolved a permanent magnet in close proximity to the ends of soft iron cores, around which were wound coils of wire. He was followed in quick succession by Saxon, Clark, and Page, and later by Wheatstone and Cooke, all of whom invented machines in which the currents were produced by the mutual action of magnets and soft iron, one or the other being surrounded by a coil of wire.

In 1842 Elias produced a machine which is the forerunner of some very successful machines of the present day. This consisted of two rings with six projections on each, one ring being inside of the other, and the projections of the outer ring facing towards the centre, and of the inner ring outwards. The intervening spaces were wound with wire, the direction of winding being reversed in alternate sections. A current being passed through the coils, the projections became poles of a compound ring magnet, alternating north and south. Consequent attraction and repulsion with rotary motion resulted, and when the polar extensions were opposite each other the direction of the current in the coils of the inner ring was reversed, changing the poles, and thus keeping up the rotation, there being as many reversals as there were polar extensions on the ring in one revolution. This machine, however, was designed as a motor, and was not used for the generation of a current.

Then came Schottlaender, Stöhrer, and others, with modifications of the Pixii machine, using a large number of magnets and coils. In 1845 it occurred to Wheatstone and Cooke to use an electro-magnet instead of a permanent one, and this was excited by a battery. Nine years passed, and then Hjorth made a decided advance by designing a machine with a combination of permanent and electro-magnets, such that the current induced in the revolving coils by the permanent magnets was made to excite the electro-magnets, the first

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attempt at self-exciting. In 1856 the Siemens armature was made, consisting of a long cylinder of small diameter, with two longitudinal grooves cut in it, and filled with wire. In the same year Holmes brought out an improved Alliance machine, consisting of a number of coils on a disc, rotating in close proximity to a number of permanent field magnets, and in 1862 this was used for lighting the Dungeness lighthouse.

In 1858 some unknown person proposed to use the whole of the current generated for the purpose of, in whole or in part, exciting the electro-magnets. About thirty years had now elapsed since Faraday's announcement of his discovery, and all the efforts made had only resulted in producing machines embodying the principles of the first, and depending upon the magnetisation and demagnetisation of magnet cores. Partial self-excitation had also been made possible, and true auto-excitation shadowed forth.

The year 1860 marked a new discovery or invention, one which is the prototype of a large number of the best modern dynamo machines, but which was, like the Elias invention, intended for a motor. This was the design of Pacinotti, which was publicly described four years later. The most interesting and important feature is what he calls a "transversal electro-magnet." This is a ring of soft iron, enveloping which is an endless spiral of wire. Supposing the ring and spiral cut and straightened, there would be an ordinary electro-magnet, with strongly marked poles at the extremities, when a current was passed through the wire. If the ring be again formed, the ends of the coil rejoined, the poles would be no longer apparent, even supposing a current circulating. That is, it would be a closed magnetic circuit. If, now, the wire at two extremities of the diameter of the ring be denuded, and contact be made at these points by the terminals of an otherwise complete circuit, the current would divide and pass in opposite directions around the two halves of the ring. There would then be developed two unlike poles, one at the point where the current entered and one where it left; that is, there would be formed a ring magnet, which might be considered as composed of two semi-circular electro-magnets, placed together, like poles to like. If the current were allowed to enter or leave at the extremities of any other diameter, poles would be as readily formed at these points. Now, by taking a wire from each bight, or coil, to a small piece of metal on the axis, and ranging the pieces in the same order as the bights, two strips of copper could be made to traverse successively the strips, if the ring were made to rotate and the points of current entering and leaving, and consequently the poles of the ring could be made to travel around the ring progressively. This was mounted on a spindle, and placed between the poles of an upright electro-magnet, and the connections were such that the current was passed through the magnet coils and the ring coils in series, as in many dynamo machines. The ring was provided with projections between the coils to bring the poles nearer to those of the electro-magnet. The brushes, which rested on the commutator strips, were so placed that the poles should be formed so as to cause attraction and repulsion. A current being passed through this machine rotation ensued, and the position of the poles in the ring shifting as fast as the ring rotated, they maintained a fixed position with regard to the electro-magnet. The effort of rotation was something like that of a man on a treadmill.

The reasons given by Pacinotti for constructing this machine were as follow:—

1. That according to this system the electric current is continually traversing the coils of the armature, and the machine is kept in motion, not by a series of intermittent impulses succeeding one another with greater or less rapidity, but by a constantly acting force producing a more uniform effect.

2. The annular form of the revolving armature contributes (together with the preceding method of continuous magnetisation) to give regularity to its motion, and at the same time reduces the loss of motive power through mechanical shocks and friction to a minimum.

3. In the annular system no attempt is made suddenly to magnetise and demagnetise the iron core of the rotating armature, as such changes of magnetisation would be retarded by the setting up of extra currents, and also by the permanent residual magnetism, which cannot be entirely eliminated from the iron; and with this annular construction such changes are not required, all that is necessary being that each portion of the iron of the ring should pass in its rotation through the various degrees of magnetisation in succession, being subjected thereby to the influence of the electro-dynamic forces by which its motion is produced.

4. The polar extensions of the fixed electro-magnet, by embracing a sufficiently large number of the iron projecting pieces on the armature ring, continue to exercise an influence upon them almost up to the point at which their magnetism ceases when passing the neutral axis.

5. By the method of construction adopted, sparks, while being increased in number, are diminished in intensity, there being no powerful extra currents produced at the breaking of the circuit.

Dr. Pacinotti further pointed out that when rotating a continuous current was generated in opposition to the battery current. By replacing the electro-magnets by permanent magnets and rotating the ring mechanically the machine would generate currents of electricity.

The direction of the current generated was reversed by reversing the direction of rotation. That of the machine was reversible. One of Pacinotti's machines, a copy he made, was exhibited at the Crystal Palace. Twenty years have passed since this inventor made these discoveries, and it has only been in recent years that he has received at all general recognition for his remarkable discovery. It may be interesting to note the resemblance existing between the Pacinotti ring and that invented by Elias nearly twenty years before.

Two years after the publication of the system of winding and commutator connections devised by Pacinotti, Baron Worms de Romilly patented systems of winding the armature of electric generators, embracing two entirely distinct methods, one of which being the forerunner of the Gramme, and the other of the Siemens or Hefner-Alteneck system.

In the first of these the coils were wound so as to entirely enclose an annular or cylindrical shell, which rotated between outer and inner permanent magnets. In the other, the coils were wound longitudinally along a cylinder, opposite parts of a coil being on opposite sides of the cylinder.

A modification of the first method was a flattened ring, the active parts of the coils being radial, and the magnets being placed at the sides or ends of the ring. A commutator was proposed, but it does not seem to be like the Pacinotti type, for all the coils have the current changed at the same time.

In 1866 and 1877, Varley, Wheatstone, and Siemens, independently, and practically simultaneously, announced in different ways the discovery of the self-exciting principle, one of the most important for practical purposes; and in the latter year Wilde built a machine in which he used a large and small armature, the smaller rotating between the poles of a permanent magnet and exciting the larger electro-magnet. In the same year Ladd devised a machine with two armatures rotating between opposite ends of the same electro-magnets, one supplying the exciting circuit, and the other the external circuit.

We have now come to the year 1870. Most of the machines devised in the forty years following Faraday's discovery, although ingenious, had defects which made them impracticable for the demands of electric lighting, and they generally, if not all, depended on the mutual action of magnets and soft iron—that is, upon the sudden magnetism or demagnetisation of cores which were surrounded by coils of wire. The currents while energetic were really suddenly created or destroyed; the commutation of such alternate currents was accompanied by great sparking and waste; the continuous current resulting was made up of a series of powerful impulses, and there was a great amount of heat developed in the magnet cores. A few of these machines have been since developed into practical generators, but may be considered as obsolete. The Romilly patent had suggested the longitudinal cylinder coils, the radial and ring coils, and the labours of Pacinotti most distinctly pointed out the way for the prac-

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tical construction of a truly continuous current machine, and the reversibility of electro-motors and generators.

The principle of self excitation from the residual magnetism of soft iron had also been established; yet with all this experience it was not until six years after the publication of Pacinotti's work that a really continuous current practical electric generator was brought forward, and in a short time developed into a pure dynamo with self exciting electro-magnets. And the credit of it is due to M. Gramme.

The year of 1870 marks a new era in the progress of electrical science, and one in which the advance has been very great. Gramme was followed in 1872 by Hefner-Alteneck with a new and ingenious and highly powerful type of machine, now familiar under the name of the makers—Siemens. Then came the labours of Lontin, Farmer, Wallace, Lachaussée, and De Meritens on the older form of machines, of whom the latter is the most successful; and of Weston, Farmer, Maxim, Edison, Brush, Seeley, Bürgin, Schuckert, Heinrichs, Gülcher, Jablochkoff, and a score of others beside; the continued labours of Gramme and Siemens, on the newer forms, or on machines involving to a greater or less extent the main principles of construction and working of the Pixii, Elias, Pacinotti, Romilly, Gramme, and Siemens generators.

I will first give some account of the principles governing the generation of electricity, and a general classification of machines, reserving for individual notice more detailed accounts of the construction and theory of action of such of the modern machines as were exhibited at the Crystal Palace.

Principles and Classifications.

Broadly speaking, an electric generator is a machine for converting mechanical energy into electrical energy, and such conversion is made by the influence of a magnetic field on the conductor of closed circuit. That there may be any such influence brought into operation it is necessary that there should be a change in the magnetic field with respect to the conductor on which it operates. If such a change of magnetic field is made, then a current will be induced in the conductor, whose direction and strength of energy is determined by the quality and amount of change. Every magnet—and we may say that all iron is more or less magnetic—and every conductor in which a current is flowing is surrounded by a magnetic field, and the object desired is to make the most effective use of the strongest field.

We know that when a wire encircles a mass of iron, if the magnetic state of such iron is changed, electric energy is immediately made manifest in the wire, but disappears at the instant the change is completed. So, too, if a conductor is moved in proximity to a wire which is conveying a current, a current is induced in it, depending for its direction on the relative motion of the wires and the direction of the inducing current. Or if two wires are near each other, and a current is established or broken, or its strength changed in one, a current is induced in the other. Again, if a conductor is made to pass the end of a magnet, a current is established in it whose strength and direction is dependent upon certain conditions. Now, what causes all these currents, and why do they change in direction and strength? To follow Faraday's description, a magnetic field may, for all practical purposes, be considered as made up of lines of force. In the case of the free magnetism apparent in iron these lines may be looked upon as lineal. By this I do not mean that the vibratory or vertical movements of the ætheric medium, which conveys electrical manifestations, take place in right lines, for the vibration has probably a spiral or rotary character; but rather that if mapped out, say by means of iron filings, the resultant would show magnetic efforts taking place in lineal directions. These lines are not parallel; but, considering one pole of a magnet, diverge, seem to repel each other, and take the most direct path possible, their divergence and the intervening medium being considered, to the opposite pole. The field surrounding simple conductors is either rotatory or spiral in character. In the case of iron this field may be much changed and intensified by the introduction of a mass of iron, through which the lines of force seem to pass most easily. If a conductor is so moved that a line of force is crossed, a current will be induced in it, and the greater the number of lines cut in a given time the greater will be the activity of the current. The action of conductors upon each other, and of iron upon wire surrounding it, although dependent upon the production of a magnetic field, does not seem so clear; and although I have formed ideas concerning it, I will not attempt their discussion. In the ordinary magnetic field the number of lines of force cut in a given time depends upon the strength of the magnetic field, direction of motion of conductor, velocity of the conductor, and the strength of the current further depends upon the length of conductor. If, then, a generator depends entirely upon the motion of a conductor in a fixed field, the field should be made as strong as possible, reasonably speaking —as much of the field as can be should be called into play; it should be intensified and made regular by the introduction of iron near the magnetic poles; and a long conductor should move at a high velocity at right angles to the strongest field.

So, too, with magnet cores does intensity of current depend on rapidity of change, strength of magnet, length of convolutions, and their proximity to the core.

On the other hand, the object of a generator is to produce a current where chiefly required in a part of the conductor outside of the machine, that is in an external circuit. We have, then, to consider which of the elements useful in producing electric action are disadvantageous.

Just here, however, let me speak of the quantities we have to deal with. These are simply—Electromotive force, current, resistance. The first is what is called into play by the motion of a conductor in a magnetic field, and is the force which tends to make a current circulate in a conductor. It exists in a battery at rest as well as when in action, and may be certainly regarded as in existence in a conductor moving in a field, even though the circuit is not closed. It is a potential, an unequilibrium of electric energy, which, on a path being formed, tends to equalisation. If such a path is opened, energy is immediately made manifest in the form of current, a transition of ætheric vibration over a conductor. This current is dependent upon two elements, the E.M.F. or potential, which is endeavouring to restore equilibrium, and a third quantity, resistance—that quality of a conductor which opposes the free electrical vibration. These quantities, or qualities, are mutually dependent, or rather the current may be better considered dependent on the other two. If expressed as an equation this relation becomes Ohm's law,

$$C = \frac{E}{R}.$$

A current passing over a conductor always does work, and the amount of this work is determined by the strength of the current and the resistance offered in its passage. With a given resistance it varies as the square of the current; with a given current it varies with the resistance. Now the work done appears in the evolution of heat, and unless the heat can freely radiate, the conductor and any metallic masses in contact with it must rapidly heat. If long conductors are used in small spaces they must take the form of convolutions superposed one on another. Hence it becomes necessary to depend to a great extent upon high speed and strong magnetic fields rather than upon length of conductor, when moderate electro-motive forces are produced. Where high external resistance must be overcome the high speed and magnetic field are insufficient, and then long conductors must be used. But where those high electromotive forces are used the currents are small, as in the transmission of energy over long distances, and, on the other hand, in practical work, such as electro-plating and incandescent lighting on the multiple arc system, low electromotive forces are attended by heavy currents.

High conductor speed may be obtained either by a high angular velocity—that is, by a large number of revolutions per minute, or by large dimensioned moving parts. To the first there is of course a limit, and this limit is the more quickly reached if the moving parts are driven directly from the source of motive power, instead of through the medium of

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belting and gearing. On the other hand, compactness and handiness of parts put a limit also to the size of these, and a medium must be struck depending upon the circumstances under which a generator is to be used.

(TO BE CONTINUED.)

ELECTROLYSIS OF SULPHURIC ACID IN ACCUMULATORS.

Some time ago Professor Frankland suggested that in charging and discharging accumulators hexabasic sulphuric acid was electrolysed. Dr. Gladstone and Mr. Tribe have carried out some experiments in this direction with sulphuric acid of a strength of 4·2 per cent. Their apparatus consisted of a U tube having a stop cock in the centre of the horizontal portion. The hole in the stop cock was so packed with asbestos as to prevent mechanical mixing of the liquids in the two arms of the tube or endosmose. With currents of different strengths they notice that the increase of sulphuric acid in the positive compartment per equivalent of hydrogen set free decreased with the lowering of the current strength. In other experiments with sulphate of copper in one arm and sulphuric acid in the other, they found that the acid accumulated was largely in excess of the copper deposited, this being due to the unequal transference of the ions. From these results and those obtained by other experimenters, they conclude that the electrolytic method is incapable of determining whether dilute sulphuric acid, H_2SO_4, or a hydrate thereof, gives rise to the current; and moreover, from other experiments with copper and zinc sulphates, in which both arms of the U tube were filled with the same solution, they show that neither the composition nor even presence of a hydrated salt in aqueous solution can be determined by this method.

THE IRIDIUM INDUSTRY.*

By WM. L. DUDLEY, Cincinnati, O.

It is my desire to call attention to a new industry which was started about four years ago, through the discovery by Mr. John Holland, a resident of this city, of methods suitable for working the metal iridium. This metal has been known since the year 1803, having been discovered by Smithson Tennant while investigating the metallic residue which remained when platinum ores were dissolved in aqua regia. The metal is classed among the rare metals, as it is not found in large quantities, although it is quite widely distributed geographically. It is found in California, Oregon, Russia, East India, Borneo, South America, Canada, Australia, and in certain parts of France, Germany, and Spain. The principal sources of supply of the metal are Russia and California; it is nearly always found with either platinum or gold, is extracted from those ores as a by-product, and is always found in small grains or fine powder, the largest pieces being about the size of a grain of rice. In nature it is generally alloyed with other metals, and the two metals with which it is most commonly alloyed are platinum and osmium; the platinum alloy is called platin-iridium, and the osmium alloy osmiridium, or iridosmine. The grains of platin-iridium are sometimes found as small cubes with rounded edges, while the iridosmine usually exists in the form of flat irregular grains and occasionally as hexagonal prisms. The supply of metal which is derived from Russia is generally obtained from the platinum mines which are situated in the Ural Mountains; while in California it is found principally in the placer gold-washings. The ores of iridium are a source of great annoyance when mixed with gold dust on account of its specific gravity, which is about 19·3, being nearly the same as that of gold. Consequently, it is impossible to separate the gold from the iridium by the process of washing; the separation may, however, be made either by the amalgamation of the gold (as neither iridium nor its ores combine with mercury) or by dissolving out the gold in aqua regia.

In the mints these metals are frequently separated by melting the gold dust and allowing the molten mass to remain in the crucible for some time, during which the iridium slowly settles to the bottom, as it does not alloy with the gold under such circumstances. The gold is then poured off from the top, and the dregs in the bottom of the crucible are found to contain the greater quanity of the iridium. The gold contained in the dregs is then dissolved and the iridium is found in the residue.

In Russia it is contrary to the law to possess or deal in iridium ore, and consequently the Government takes possession of all the ore which is mined or extracted from the platinum ores in that country, and it is stored in the vaults of the Royal Mint. The reason for the law is, that some years ago the Russian Government found that speculators in gold-dust would sometimes add iridium to it (which often escaped detection by the officials of the mint), for the purpose of increasing its weight. On attempting to work this gold they found the fine particles of iridium distributed through the ingots; on rolling the ingots into sheets, these individual grains or particles produced indentations in their steel rolls; and in striking out the coins the dies were marred and defaced, thus causing considerable loss to the Government. In order to prevent this species of fraud, the Government passed a law prohibiting persons from handling the metal in any way and compelling its immediate surrender.

For a number of years experimenters have endeavoured to melt the iridosmine or iridium in order to utilise it in the arts for such purposes as could with advantage employ a metal of its wonderful properties; but until lately success has been only partial.

I may here briefly describe the properties of the metal itself. Iridium possesses a white lustre, resembling that of steel; its hardness is about equal to that of the ruby; in the cold it is quite brittle, but at a white heat is somewhat malleable. It is one of the heaviest of metals, having a specific gravity of 22·38. When heated in the air to a red heat the metal is very slowly oxidised; but upon raising the temperature to about 1,000 C. it parts with its oxygen, and hence at a high heat (above 1,000 C.) it is not oxidised. It is insoluble in all single acids, but is very slightly soluble in aqua regia after being heated in the state of fine powder for many hours. In a massive state, however, aqua regia does not attack it.

In attempting to fuse iridium heretofore, it has been found by experimenters that the best results that could be obtained were by means of the oxyhydrogen or electro furnaces, but that with either of these means of fusion they could only work a very small quantity of the metal at a time, and obtain a globule of very small size. Previous to the present time iridium has had substantially but one use (with the exception of alloying with platinum), viz., for pointing gold pens. The iridium point is commonly called "diamond point" upon a gold pen, and it consists simply of a small grain of iridosmine which has been selected for the purpose, and soldered to the tip of the pen. These are selected by first removing from the ore, with a magnet, the magnetic oxide of iron which always accompanies it, and then dissolving out, by means of acids, the other impurities which may be present; the ore is then washed with water, dried, and sifted in order to remove the fine dust, and the sifted ore is then ready for the selection of points. This is done by an operator, who rolls the grains of iridium around with a needle point, examining them under a magnifying glass, and selecting those which are solid, compact, and of the proper size and shape. These points are usually selected in three grades, small, medium, and large, depending upon the size of the pen for which they are intended to be used. The grain of iridium having been soldered on to the end of the pen, it is sawn in two (which makes the two nibs of the pen), and ground up in the proper shape.

About four years ago Mr. John Holland, the well known gold pen manufacturer, found it necessary to have pieces of

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iridium larger than those generally found in nature for the purpose of making points for the Mackinnon stylographic pen. After many experiments he found that by heating the ore in a Hessian crucible to a white heat and adding it to phosphorus, and continuing the heating for a few minutes, he could obtain a perfect fusion of the metal, which could be poured out and cast into almost any desired shape. This material was found on physical examination to be about as hard as the natural grains of iridium; and in fact seemed to have all the properties of the metal itself. On chemical analysis it was found that the metal fused with phosphorus contained, according to two determinations, 7·52 per cent. and 7·64 per cent. of phosphorus. At this stage of the discovery we became acquainted with it, and began experiments with the intention of putting the product to some practical use in the arts. It was found that the presence of phosphorus rendered the metal quite readily fusible at a white heat, but this, of course, was an obstacle in the way of its use for electrical purposes. Desiring, therefore, to remove the phosphorus, we found by experimenting that by heating the metal in a bed of lime the phosphorus could be completely removed. In this operation the metal is first heated in an ordinary furnace to a white heat, and finally, after no more phosphorus makes its appearance, it is removed and placed in an electric furnace with a lime crucible and there heated until the last traces of phosphorus are removed; the metal which then remains will resist as much heat without fusion as the native metal.

In mechanical applications, where the metal is not subject to great heat, it is melted with phosphorus and cast into the shape desired, and then ground or worked as the application may require. The first application to which it was put was for the manufacture of the Mackinnon pen-points. For this purpose, the metal, after being fused, is removed from the furnace and poured between two slabs of iron which are kept apart the desired distance so as to make a sheet of iridium of the thickness required. The metal is poured, as I have said, between these plates, and the plates are brought suddenly together on the plan of a closed ingot with a hinge, so that as the metal cools it is subjected to pressure which closes the pores and makes a very compact casting. The slabs for the Mackinnon pen-points are about one thirty-second of an inch in thickness, and are broken up into small irregular pieces, which are soldered on a strip of brass, and ground down to a flat surface by means of a copper lap. The copper lap consists of a plate of copper, about one-half inch in thickness and eight inches in diameter, fixed on a spindle, which is made to revolve from eight hundred to a thousand revolutions per minute. The copper of which the lap is composed is wrought copper, well annealed, and consequently very soft. In order to grind with it, corundum or diamond dust is mixed with oil and applied to the flat surface of the lap by means of a flat steel instrument, upon which pressure is applied in order to force the corundum or diamond dust into the copper, thereby making a cutting surface. The iridium to be ground is held against this sharp surface of the lap, and the corundum or diamond dust gradually cuts the metal away. As the cutting material wears from the copper lap, another application of the corundum and diamond dust is made by means of the steel instrument as described; this operation is continued until the grinding is complete. After the slabs are ground to a surface they are then drilled. In the drilling operation, the iridium is first countersunk by means of a diamond drill, consisting of an upright spindle suitably fixed in a frame so as to revolve freely; the bottom of the spindle holds a small rod of brass, to the lower end of which is set a white diamond-splint. This drill is made to revolve about nine hundred revolutions per minute. The iridium is held up against the diamond with a light pressure, and the diamond gradually makes a conical hole or countersink. After countersinking the iridium, it is finally pierced by means of a copper drill, which consists of a piece of soft copper wire, which is filed down to a point and set in a drill similar to that in which the diamond is placed, but this drill makes about thirty-five hundred revolutions per minute. Corundum or diamond dust and oil is put into the countersink opening in the iridium, and then it is held up against the piece of revolving copper. The diamond dust or corundum, embedding itself in the copper, acts as a cutting surface, and finally accomplishes the drilling of the hole. The holes having been drilled in the pieces of iridium which were soldered to the brass, the brass is finally dissolved from the iridium by means of nitric acid, and then we have irregular-shaped pieces of iridium, pierced with holes. These pieces of iridium are then soldered in proper position to the end of the Mackinnon pen, fitting into the opening of which there is a valve consisting of an iridium-pointed wire. The iridium is then ground to the proper shape on the outside by means of a copper lap, consisting of three or more copper cylinders on a common spindle, making about three thousand revolutions per minute.

The operation of sawing iridium is carried on by means of a copper disc, from four to eight inches in diameter, made of soft thin sheet copper, held between two clamps, placed on a spindle revolving at the rate of about twenty-five hundred revolutions per minute. This sheet of copper revolves in a box which contains corundum or diamond dust and cotton-seed oil. The cotton-seed oil with the cutting material adheres to the periphery of the saw, and as the saw comes in contact with a piece of iridium it gradually does the work. Cotton seed oil is preferred for this purpose to any other oil, on account of its viscosity.

I may mention briefly some of the uses to which iridium has been applied. First, I will refer to the draw-plate for drawing wire. There are at present, besides the iridium draw-plate, the ordinary steel plate which is used for drawing heavy wire, and the ruby plate, which is used in drawing gold and silver wires, where it is desirable to have them of uniform thickness. The iridium plate is made somewhat similar to the ruby plate, consisting of a piece of iridium which has been countersunk and drilled in the usual way to the size of the hole required, and set in a brass plate, where it is firmly held by a bushing. This plate is now coming into use, and is rapidly taking the place of the ruby plate, being equal to the ruby in hardness and much more durable, since it is less liable to break or chip by rough handling or heating.

Iridium knives are made for fine scales and balances, the bearing edge of which consists of iridium, soldered firmly to a brass body. These are rapidly taking the place of the agate for fine chemical balances, and there seems to be no reason why they should not have even a more extended use, since they are superior to the agate in that they take a finer edge and thereby make a more delicate balance, and are not so liable to crack or break. They are now being used altogether by Mr. Henry Troemner, of Philadelphia, the well-known scale manufacturer, for the purpose of adjusting his weights for all of his scales.

Hypodermic needles for physicians' and surgeons' use are now made of gold and tipped with iridium, in place of the old steel pointed ones, which are liable to rust or corrode if not properly taken care of. The iridium being hard will take a good edge, and is not subject to corrosion, as is steel.

Styluses for manifold writing are also being made with iridium points, having decided advantages over either steel or agate. Iridium points are also being applied to surveyors and engineers' instruments, and in all places, in fact, where hardness, durability, and non-corrosibility are required. For all the above uses the iridium alloyed by fusion with phosphorus is employed.

Some years ago experiments were made in order to apply this metal to the electric light. We found that an iridium electrode used upon the negative of an arc light would keep its shape and resist the heat, provided the positive carbon which was used with it was not allowed to strike or fall too heavily upon the iridium negative. Since the metal at a white heat becomes malleable, a continual pounding or striking would gradually beat the negative out of shape. The iridium negatives are made by setting a piece of dephosphorised iridium in the end of a brass rod about six inches long and nine-sixteenths of an inch in diameter. The length of the iridium is about half an inch, ground conical in shape. It was found that the brass, being only half an inch from the arc, would resist the action of the heat; but in some cases where the lamp flamed the brass was liable to undergo partial fusion; and in such cases it was found desirable to put a thimble

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or cap of platinum over the end of the brass and just below the iridium, the platinum thimble being about half an inch long.

One of the most important applications of iridium which has yet been made is to the electrical contact-points of telegraphic apparatus. These contact-points consist of pieces of copper wire tipped with iridium, which are set in the instrument just as platinum points are set. These contacts will outlive many platinum contacts, are not subject to oxidisation or sticking as are the platinum ones, and all that is necessary in order to clean them when they become dirty is to pass over their surface an emery file or a piece of fine emery paper. These contacts have been thoroughly tested by various eminent electricians and also by long-continued use, and the advantages herein stated have been in every case fully demonstrated.

In the past three years we have been experimenting on methods of plating with iridium, and about one year ago we succeeded in obtaining a bright reguline deposit of iridium on base metals. This deposit resembles the natural metal, being quite hard, and resisting the action of acids. There were many difficulties encountered in accomplishing this result, on account of the power of the metal to resist the action of the solvents; but we have succeeded in obtaining a solution which gradually attacks an anode of iridium, and it is hoped in a short time that all the minor practical difficulties will be overcome in the plating of articles on a commercial scale. So far, we have been thoroughly testing our results, and do not feel prepared to place our work before the public until it is perfect in all its details.

LEGAL.—The Universal Electric Company (Limited).

In the Court of Session, Edinburgh, on the 12th inst., before the Lord President and Lords Mure and Shand, a note was presented to the First Division, on behalf of Thos. Wilson, accountant, Glasgow, and Alex. Murray, C.A., Glasgow, joint liquidators of the Universal Electric Company (Limited), asking the authority of the Court for the removal from the list of contributories of the names of David Corse Glen, Robert Sorley, and David Whyte, the liquidators being satisfied that those persons were not properly entered upon the register of shareholders, and that the company could not succeed in establishing liability against them. Authority was also asked to give effect to certain compromises proposed to be effected by the liquidators of claims against certain debtor-shareholders of the company.

The Court sanctioned the deletion of the names requested, and continued the other matter contained in the note until the following week.

Counsel for the liquidators: Mr. Shaw. Agent: John Gill, S.S.C.

The Direct United States Cable Company (Limited).

Report of the directors for the six months ending June 30, 1884, to be presented at the fourteenth ordinary general meeting of the Company, to be held at the Cannon-street Hotel, Cannon-street, on Friday, 25th July. With this report the directors submit the usual statements of account for the half year ending June 30, 1884, which, with the half year's accounts to 31st December last, presented at the ordinary general meeting on the 8th February last, show the financial result of the seventh year's working of the Company. The revenue for the half-year, after deducting out-payments, amounted to £68,573 8s. 11d. The working and other expenses for the same period, including interest on debentures and income tax, but exclusive of cost of repairs of cable, amounted to £19,750 2s. 10d., leaving a balance of £48,823 6s. 1d. as the net profit of the half-year, making, with £3,524 8s. 6d. brought forward from the previous half-year, a total of £52,347 14s. 7d. Three quarterly interim dividends of 1¼ per cent. each, amounting to £45,532 10s., have been declared and paid at the usual times during the financial year, and a final dividend of 5s. per share is now proposed, making, with the three interim dividends, 5 per cent. for the year, being a total distribution of £60,710. The appropriation of the above balance of £52,347 14s. 7d. on the revenue account is thus shown:—Interim dividend for quarter ending 31st December, 1884, £15,177 10s.; final dividend now proposed, £15,177 10s.; carried to reserve fund, thereby increasing it to £360,000, £19,030 15s. 11d.; final balance of liquidation expenses, £175 10s. 1d.; carried forward to next account, £2,786 8s. 7d.; making a total of £52,347 14s. 7d. The interruption in the short section of cable mentioned in the last report has been repaired, and the cost of the repair, £5,127 18s. 9d., has been charged against the reserve fund. The final meeting of the liquidators, closing the liquidation and dissolving the old company, took place on the 17th ult. The repayment of the £100,000 six per cent. debenture loan will be made on the date due, viz., 15th October next.

Two of the directors, Messrs. William Ford and C. J. Gunther, retire by rotation, and being eligible, offer themselves for re-election.

Mr. John G. Griffiths and Mr. John Sawyer, the auditors, retire by rotation, and offer themselves for re-election.

West Coast of America Telegraph Company, Limited.

The Directors present to the shareholders the accounts for the year ending 31st December, 1883, showing the gross revenue to be £57,338 12s. 1d., against the sum of £38,908 2s. 10d. for the previous year, or an increase of £18,430 9s. 3d., and leaving a net balance of profit, after paying debenture interest and all other charges, of £23,314 9s. 7d. The Board declared in January last a dividend of 4 per cent., or 8s. per share, which absorbed a sum of £12,000 out of the net balance of £23,314 9s. 7d. The remainder has been absorbed in forming a reserve fund, and in discharging the last of the liabilities caused by the war and the consequent cessation of the Company's business. The reserve fund amounts to a nucleus of more than £10,000. Since the 31st December last the Board announce a further improvement in the position and prospects of the Company. For the six months ending the 30th June the receipts amount to the sum of £25,850, or—including the sum of £4,400 received from the Chilian Government—£30,250 against a sum of £23,450 for the corresponding period of last year, showing an increase for this year, so far, of £6,800. Out of this the Board have declared a dividend for the half-year at the rate of 4 per cent. or 4s. per share, which will absorb a sum of £6,000. This dividend is payable on the 25th inst. Mr. Matthew Gray having resigned, the Directors have elected Mr. Henry Roberts in his stead. The members retiring by rotation are Mr. R. Kendal and Mr. H. Roberts, both of whom offer themselves for re-election. The auditor, Mr. J. Weise, retires, and is eligible for re-election.

COMPANIES' MEETINGS.

Eastern Telegraph Company (Limited).

The twenty-fourth half-yearly ordinary general meeting of this Company was held on Thursday, July 10, 1884, at the City Terminus Hotel, Cannon-street, London, under the presidency of John Pender, Esq., M.P.

The SECRETARY (Mr. Draper) read the notice convening the meeting and the minutes of the last two meetings, which were signed by the chairman.

The directors' report having been at the request of the meeting taken as read,

The CHAIRMAN said: Before submitting the resolution for the adoption of the report, I wish to give you a little further information on the different items in the report. The details given, however, are very full, as I dare say you will all admit; still, there are some points that I should like to refer to. Our revenue for the six months ended 31st March last amounted to £345,156, against in the corresponding period of last year £328,404, being an increase of £16,752. This increase is largely due to the expedition undertaken by the British Government in the Soudan and the continued occupation of Egypt by the British troops; also to the gradual development of the general traffic. As to the expenses, the ordinary working expenses of the half year amounted £90,482, against in the corresponding period of 1883 £87,827, being an increase of £2,655, which includes a charge of £2,410 for expenses as to the issue of the 4 per cent. debenture stock. The increases and decreases are shown as follows:—The general expenses in London show an increase of £528. This is caused by increased law expenses in this period in connection with the action brought against the Company by the Central News Company, judgment for which has been given in our favour. The working expenses at the stations show an increase, but several of the other items show decreases. These expenses, however, include the working of two additional stations, viz., Suakim and Glasgow. A greater number of clerks have been home on leave of absence and sick leave, necessitating more changes among the staff between one station and the other. The depreciation of cable stores shows an increase of £210. A larger stock of cable had to be depreciated this year than last. The expenses of electrical exhibitions were £446. In connection with the cholera in Egypt the expenses were £101, and there are other items making up this increase. But, on the other hand, there is a decrease in the following items:—For use of patents, £6; foreign agencies, £445; maintenance ships' reserve fund, £1,000; staff endowment assurance, £77. The important point is the expenses attending the repair and renewal of cables. That amounted to £37,113, against £50,901 in 1883, or a decrease of £13,788. We carry to the general reserve fund £65,000, making that sum with interest on investments £614,170. From this amount, as explained in paragraph 5 of the report, the directors have applied the sum of £300,000 in part payment of new cables, leaving the general reserve fund at £314,170. The total amount of reserve funds, including the Sardinian cable and other special reserves, is now £349,777. The investments against this, as shown in Abstract D, are £328,574. In addition to this, £100,000 had been previously taken from the fund in part payment of expenditure on the Aden-Bombay duplicate cable. I may mention that taking the £400,000 from the reserve fund instead of adding it to capital, taking it all round, it is something like a saving to the Company of £10,000 a year, which is available for dividend, and which would not have been the case had we not taken that sum. Since the amalgamation of 1872, the ordinary working expenses have averaged nearly 26 per cent. of the revenue, and the repairs have averaged 11 per cent. The average cost of repairs to cables since 1872 amounts to £55,000 per annum, or something like £3 per mile. The total working expenses, including the expenses of the four maintenance ships, have been about 37 per cent. The average amount carried to reserve fund has been £50,000 per annum. The number of stations in 1881 was 42, and in 1884 it was 50. The number of the staff at the stations in 1881 was 419, and in 1884 the number was 533. There

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are six grades or classes among our *employés*, and the average salary of each man, excluding superintendents, is £109 per annum. The following cables have been laid since March, 1881: the Malta and Tripoli, 204; the Trieste and Corfu, 303; the Alexandria and Port Said, 153; the Suez and Aden, No. 3 cable, 1,402; connecting Suakim, 178 miles, making a total of 2,440 miles. The present length of cable, including the Black Sea, is about 19,000 miles, and the land lines about 3,000 miles. That is a very remarkable growth in the history of your Company. As you remember, there were some opinions expressed when we issued our £500,000 of debentures.

The SOLICITOR: Debenture stock.

The CHAIRMAN: Debenture stock. That stock was issued partly to pay off the 6 per cent. debentures, and partly to pay amounts which were incurred in the extension of the lines I have just mentioned to you in that 2,000 odd miles. Some thought it was a very bold thing to issue 4 per cent. debenture stock, but I am very happy to say that every shilling of that stock has been taken up, and more would have been taken up if we had had it to allot. I think it will be interesting to you to know how we have dealt with that £500,000, as the more information we give the more I am sure you will appreciate the position. Over expenditure of capital prior to September, 1881, required £28,090; redemption of 6 per cent. debentures £232,000; additions to new buildings at Suez, £3,983; Trieste and Corfu cable, £66,935; Malta and Tripoli cable, £29,268; Alexandria and Port Said cable and Suez Canal and other land lines, £36,799; Suez-Aden triplicate cable and the Suakim diversion £317,716; new stations, £812; increase of stock of cable in hand, £9,850; Direct Spanish Telegraph Company's shares, £39,237; Mediterranean Extension Company's shares, £3,498; addition to working capital invested in spare cable, £6,806, less taken from the reserve fund £300,000. On the other hand, we have spent £775,000. Taking the £300,000 from the reserve fund, that amount is brought down to £475,000, out of the £500,000 of debentures. I think all these figures give you a pretty good idea of the financial position of the Company, and although I have given you all these figures, and you have been given very full details in the report, I think it occasionally my duty to refer to one or two points in the report. As you are aware, we have established two new stations. One is at Glasgow. It may strike some of our shareholders as going a little out of our way to establish a station there; but a very large extent of trade is done between Glasgow and India, and the result of our having established our telegraph wires is that in many instances the telegraph goes to India as quickly as to London under the old system, and in these times, when telegraphy is measured not by hours but by minutes, we cannot be one minute behind when merchants' interests are at stake. We have also a station at Liverpool, and we find that they have answered the purpose immensely well, and have been very great boons to commercial interests there. The next station we established was at Suakim. There is a long history about that, but I will not go into details. I hope, however, that you will see that there was some foresight shown in connection with that matter. We laid down a third cable in the Red Sea at a time when some people thought it was not required. I believe even some of the members of the Government in our correspondence with them thought it was not desirable; but had we not laid down that third cable in the Red Sea we should not have been able to carry one of those cables into Suakim, thus giving the Government and the country an enormous advantage of telegraph communication with Suakim later. I think that is a very important feature in the history of the management of the Company, and we have no reason whatever to regret taking our cable into Suakim, as it has given us a very fair return, besides, as a gentleman by me has just remarked, having made the Government feel that they cannot do very well without us. That is the real fact. When any important war takes place, almost the first consideration is—can we be placed in telegraphic communication with a particular place? And we are always ready to do the work when the work can be done in the interests of the Company and the country generally. The next point I have to mention is that when I last addressed you I mentioned we had made arrangements with the Greek Government for the completion of their system. It is all but completed. I can scarcely give you the names, but there are twenty-five islands now connected, which you see mentioned here (showing map). Those twenty-five islands we have connected in Greece for the Greek Government, and I think I may pay a compliment to the intelligence, and I would say the patriotism of the man now at the head of the Greek Government in placing the islands of Greece in connection with Athens by a most perfect telegraph system. Probably there will be no better telegraph system in existence when this is completed. One of the results of our visit to Constantinople in the autumn was that we have got a concession from the Turkish Government—what we call the Salonica concession—which gives us in the Mediterranean and the Levant a very strong position indeed. I need not go into any details as to that further than to say this—that this concession secures us, as long as we can do the work as well as anyone else, the doing of it. I should have mentioned when I alluded to Suakim that the Government contemplate a railway from Suakim to Berber. If that is done there is no doubt that Suakim will be a port in the Red Sea, and a very important port too. I only wish that I could say that peace was established in the Soudan, but the business is in hand. England in the past has always fulfilled her obligations, and I trust that England in the present and in the future will continue to do so. If those obligations are carefully and fully carried out, there is no doubt that that connection between Suakim and the Red Sea will be a very important system for developing the commerce of that vast continent, and commerce firmly established and properly conducted is the best security for peace in the future.

We have also had another business to deal with during the last six months, securing what I would call a preponderating interest in the Direct Spanish Company. There is a very important telegraphic communication between Spain and this country, and that was an isolated company; it stood alone. It was too small to do a great deal for itself, and still it was one of those systems we could combine and utilise with very considerable economy in our system. In the meantime, it is considered desirable to keep the Company distinct, and they have duplicated their system. For doing that they have issued debentures at 6 per cent., and we have considered it not a bad bargain, seeing that it is practically in our own hands, to exchange with the manufacturers of the cable who have got those 6 per cent. debentures. We have arranged with the Telegraph Construction Company, who manufactured and laid the new cable, to exchange our 4 per cent. debentures for their 6 per cent. debentures. I think that is not a bad transaction in the interest of the Company, seeing that it adds another important link to our telegraph system.

The next point I wish to mention is as to the Mediterranean Extension Company. That was another small link in those waters that we have got possession of. As we sat down at the Board meeting in the next room we received a telegram from Italy stating that the whole thing is completed. My notes said the thing was approved by the Government, but not yet approved by the Parliament; but the telegram that we have received is to the effect that it is approved by the Parliament. That is another very important link in our system which I think we shall turn to good account. I have spoken of the issue of £500,000 of debenture stock at 4 per cent., and I would say that that shows that our credit has been very high in the money markets of the country.

I promised when I last addressed you that, as to our connection with Egypt and the Red Sea, I might give you this time some valuable information. The valuable information is that we have completed all this system, and we have a very sound footing in Egypt, and an equally sound footing in the Red Sea. Our relations with the English Government and the Egyptian Government are such that as long as we continue to do the work in the future as we have done in the past (and I hope we shall always continue to do it better than any new company could), you may rest assured that our position is safe in commanding the traffic of the two countries. I think I need not say more on that, and I think you may be satisfied that what we have done has been done in a way to secure the best interests of the shareholders. I have another matter to refer to which will probably interest you. During the last three years (I stated that we were taking that average) the amount of work done by the Company has been almost startling. During that period the average of paying words has been 10,300,000 per annum. Just conceive what an amount of labour is required to convey those 10,000,000 words! The non-paying words for which we are not paid in our telegrams amount to 3,000,000, or a total of nearly 14,000,000 words transmitted every year during the last three years, making a daily average, including Sundays, of 38,300 words. Now, I looked at this extraordinary traffic for two reasons. First, you can conceive how much we are in the hands of the young men who are employed to convey those messages. In the second place, you can well understand during a time of war what the difficulties of maintaining this system are. And the reason I draw your attention to the subject is, not only to ask your sympathy, but the sympathy of the press and the general public, for our working under the trying circumstances in which we have been frequently placed. I allude to this to-day for the purpose of bringing before you the suit raised against us in the courts, as to which I believe you have nearly all got a copy of the evidence, which after many days' sifting placed us, I think, in a very proud position [hear, hear]. Showing you, as I have done, the difficulties we contend with, the wonder is, looking at the fact of the frequent attempts to tamper with our men, that the thing has come out as pure and satisfactory as it has. I must admit that I sympathise with a man who thinks he is first and finds he is second; but when I look at the amount of press correspondence—the pressure that is in every way brought to bear on the system—you must come to the conclusion that only one can be first; and it is very hard for that one, however well satisfied he may be that he was first, but it is very hard for us also, having two or three cables to work, that we should be forced to such enormous expense as we have been to defend an action of this kind. We have tried to keep our system as correct as possible by the business men you have. We have felt and had confidence in most of our young men; but if any gentleman, whether a press correspondent or another man, attempts to demoralise our men by giving them money to get priority of information, it rests with them and not with us, and they are not the people to come and attack us for doing what they consider an unfair thing to them. I think I have not said a hard word against those who have been suing us. It is done at enormous expense, and causes considerable anxiety, because my friend and your managing director, Sir James Anderson, has been placed as few men have been, and I think you will all agree with me that after seven days' investigation, and the decision of the Lord Chief Justice, he has no reason to be ashamed of holding up his head. I am told that the business is not at an end yet. I am sorry for it, and sorry for the gentlemen who are taking all this trouble; but let them bear in mind what I have said—let them do the best they can, and give us some little credit, as we desire to give them credit, for doing the thing well. It is better than going into litigation. No money can be so badly spent as in the way they are spending money at the present time.

I think I have gone fully into the affairs of our Company. Our ships at the present moment are not employed—that is, they are well employed when doing nothing, as far as the interests of the Company are concerned. But we have to keep them thoroughly equipped, so as to go at an hour's notice when any work requires to be done. With these remarks, I beg to move the following resolution:—"That the printed report and accounts of the directors to 31st March, 1884, submitted to this meeting, be and they are hereby received and adopted; that a dividend on the preference shares of the Company to the 30th of June, 1884, at the rate of 6 per cent. per annum be paid, less income tax; and that in accordance with the

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directors' recommendation a dividend be and is now declared of 2s. 6d. per share, with a bonus of 1s. per share, both free of income tax, on the ordinary shares of the Company, making with previous payments by way of dividends on account a total payment of 6 per cent. on those shares for the year ended 31st March, 1884."

The VICE-CHAIRMAN (the Marquis of Tweeddale): I beg to second that.

The CHAIRMAN: Before I put that motion to the meeting, if any gentleman wishes to put a question on the report, or any remarks I have made, I shall only be too happy to answer him.

Mr. DELONERGAN: I was not here when you commenced, and I have not perused this report. I see a large sum down for the laying of the third cable in the Red Sea from Suakim. I think it is from Suez to Suakim. Am I right? £300,000 it is. One would imagine that would not pay.

The CHAIRMAN: I think, sir, you have not quite listened to my observations.

Mr. DELONERGAN: I told you I was not here at the commencement of the meeting. I merely wish to ask you if there are any collateral advantages for laying that cable beyond the more traffic that will accrue from laying it, as it appears to me that by and by if peace is established it would not pay by traffic to Suakim. I wish, therefore, to know if you have any collateral advantages in consequence of laying that cable from the Government, or otherwise. I wish also to ask you if you intend to discontinue those service messages, which will create a certain amount of suspicion as long as they are continued. No one should have an advantage over another. It appears to me that the practice of those service messages brought you all this trouble and litigation that you have gone through. With great respect I will suggest that you had better discontinue them altogether. The public will have more confidence in what they are paying for. I am sorry to see that our dividend is not larger, after having all the traffic that we have had in this Company. Six per cent. appears a small thing after all the traffic you have carried, and I suggest that you should cut down the expenses as much as possible.

Mr. HURST: I think it very unfortunate that the last speaker was not present or did not attend to the chairman's remarks. If he had been we should have been spared his remarks. We have listened to and heard with great interest the chairman's speech, and I never here or anywhere else heard anything more satisfactory. The manner in which the business has been transacted—an immense business, a business of such extent that there are few in the world equal to it, to be conducted in the manner in which this has been is highly creditable to everyone concerned in it. The wonderful thing is that mistakes are not made and that such a business can be carried on with the immense amount of regularity with which it has been. A gentleman spoke of the dividends. I would say for myself—and others, I believe, would also say, remembering the past—that I think the dividend is satisfactory. Some years ago—not a great many—when we were receiving 5 per cent., the chairman held out some expectation of a slight increase. I put the question then to him whether we could not look forward to 6 per cent. The chairman shook his head and spoke doubtfully, and spoke of a small increase, but you see that that for which I expressed a hope has been fully realised, and I trust if we can go on with such a business as this receiving a constant 6 per cent. we shall do exceedingly well. If we can get our business into a sound and steady state, not like where you have a great dividend one time and none at another time, I think that that would be a matter for congratulation. This business has been conducted so well, and in such an economical manner, that the dividends seem to be perfectly steady and satisfactory. If we can go on increasing in prosperity, there will be a possibility of something additional being made; but, if that should arise, I should say that it had better come in the shape of bonus than in any increased dividend, because if you give an increased dividend, and it cannot be maintained, there is a great deal of stock-jobbing, and steady investors suffer a great deal from it. Altogether, I think we may congratulate ourselves that we hold property in as sound and substantial a business as any in England, and I trust it will continue in that way. I think the warmest thanks are due to the directors for the energy and judicious manner in which the business of the Company is transacted. As to the third cable that has been spoken of, the chairman fully explained that it had turned out profitable. With regard to economy, considering the responsibility we throw upon the *employés* of the Company, and considering the average payment they receive, I think that none of them are overpaid. I think we may sit down satisfied and feel that we are on the way to a very good business.

Mr. GRIFFITHS: A very able speech has been made to us by our chairman, and I think there is very little room for questions. I would only make one suggestion; it is founded on the last portion of our chairman's speech, as to the very unfortunate litigation into which we been dragged. I say dragged, because we are the defendants, not the plaintiffs, and I believe all the right is on our side. We are successful so far, and I hope we shall be, but no doubt heavy bills of costs will be incurred. It may be that our opponents are not men of great wealth, and if we gain the costs we may not be able to recover them. Having attended the court very frequently, and having heard most of the evidence, I have come to the conclusion that, while we are guiltless, possibly the military authorities exceeded the power which they ought to have exercised. No doubt the military ought to have the first information conveyed by the telegraph; but I think it is going a little beyond their right when they not only obtain it themselves for military purposes, but make use of it for other purposes. I wish our opponents would attack the Government rather than us.

The CHAIRMAN: Will you allow me to suggest that as this case is not yet settled, the plaintiffs having stated they will appeal, let us be generous as well as just, and not discuss the matter?

Mr. JOHN NEWTON: The gentleman who spoke before Mr. Griffiths seems to be satisfied with 6 per cent. I am not. I do think, while I endorse all the eulogiums he has bestowed on you as to the management of the Company, that 6 per cent. is not a very fair return for the capital we have invested in this Company, and also for the immense service this Company is rendering to the world at large. When we find railway companies that have not rendered great services to the community paying 8, 9, and 10 per cent., I think we ought not to be satisfied with 6 per cent. I think from the manner in which you are managing this Company's affairs that we are within sight of an increased distribution, and as to whether it should be dividend or bonus, it will be the same in my pocket whichever it is. We must not, however, be satisfied with 6 per cent. In addition to the capital there are large reserves, which all add to the strength of our Company, and I think we ought to have 6 per cent. on a capital so solidified as this.

The CHAIRMAN: A gentleman who spoke referred to the desirability of abolishing what are called "service messages." If we abolished service messages we ought to shut up our stations altogether. We manage our business by service messages, and to abolish them is impossible, and if you had sat in my seat I think you would never have uttered such a suggestion. It requires a great deal of knowledge and experience to conduct such a system as this. I am sure you have all sympathy with Mr. Newton's remarks. I have. If we go on, if we do a good deal of work, and with the property pretty well solidified, we shall begin soon to sit down and think whether there is anything further to be done. We see the end pretty well, and when we get all that in order Mr. Newton may depend that that which he sees looming in the future will be a reality. We are putting £50,000 a year to the reserve fund meantime, and if we are not putting the money into your pockets, we are in that other way strengthening the position of the Company.

Mr. DELONERGAN: You did not answer one of my questions, whether you have got any collateral advantages from the Suakim cable.

The CHAIRMAN: I made a speech in which I stated that it had already pretty well paid itself, and further that we had got such a collateral advantage that it placed the Company in such a position that, if we do the work in the future as we have done in the past, we shall be likely to have possession of that part of the sea for our submarine cable. I cannot say more. I think I have satisfied the body of shareholders that they are in a very sound position. I wish to give every gentleman a full opportunity of expressing his opinion. Last year the directors stated in their report:—"The directors have concluded an agreement with the Egyptian Government by which this Company engage to connect Suakim with Suez by one of their Red Sea cables." And the present report says:—"The connection of Suakim with Suez and Aden has been effected in accordance with the agreement entered into between her Majesty's Government, the Egyptian Government, and the Company. It is not my business to give you the minute details of this agreement. We consider they belong to the management of the Company; but we should not have put that in the report unless a satisfactory arrangement had been come to.

He then put the motion for the adoption of the Report in the usual manner, and declared it carried unanimously, and intimated that that concluded the business of the meeting.

Mr. GRIFFITHS: Mr. Chairman and gentlemen—I think we can hardly conclude the business of the day without expressing our thanks to those who have managed for us so well. I am sure Mr. Pender's speech gave us very full and very useful information; and this question of our friend, although it might be a good one, was answered before it was put. It requires no ordinary talent to conduct such a business as this, with its capital of over five millions, and its messages of over fourteen million words a year. And it is surprising that so few mistakes, if any, occur. For this successful conduct of our business we are under great obligations to our chairman. We need not discuss here the career of our chairman. It is most interesting to read how that gentleman has risen so high in the world, and has done so much for us. To us the increase of dividend is most satisfactory, and the prospect held out that Mr. Newton's hopes will be realised in time to come must be satisfactory to us all. I hope Mr. Pender will long preside over us.

Dr. WALLER: I have given way to the gentleman who most properly proposed this vote of thanks. I never rose with more pleasure in my life at a public meeting than to-day to second a resolution. Your speech, Mr. Chairman, gave us all great pleasure. It was, as it always is, lucid. It was exhaustive, and most thoroughly satisfactory. There are two or three things that have given us great pleasure. One is the question of the Suakim cable. You explained all about it as far as you could, but you did not go as far as to say anything that would be improperly discussed before a public meeting. We have great reason to congratulate ourselves on the issue of the 4 per cent. debenture stock. I will not detain you any longer, for we have been detained a long time. I shall only address myself now to one question—that is, the propriety of increasing our dividend. I am greatly satisfied with that dividend, and I hope whenever the time comes that we shall pay an extra amount it will not be in the way of dividend, but in the way of bonus as heretofore. There is no better financial barometer.

The SOLICITOR put the motion, which was carried.

The CHAIRMAN: On behalf of my colleagues and myself I have to return you our thanks. I think I can see in the feeling that has been taking place during the last two or three years increased confidence on the part of the shareholders in the management of the Company. I am proud to see that. It is what we desire above all things, and you may rest assured that as we come to our half-yearly meetings we shall keep nothing hidden from you that we think you are entitled to know; if, at any time, it should be that we have kept back anything that we ought to have brought before you, we shall stand arraigned before you. We shall give you all the information we can. I think I may say, during the sad times we have been passing through, when every stock almost in the country

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has been falling, ours has not only stood the test, but has positively advanced. That is another assurance to us and another evidence to us of the position we occupy. Taking that and the issue of our 4 per cent. debenture stock enables me to say that an investment in this Company may be reckoned among the very best investments in this country or in the city of London. I beg to thank you.

The proceedings then terminated.

United Telephone Company (Limited).

The fourth annual ordinary general meeting of this Company was held on the 15th inst., at the offices, Oxford-court, Cannon-street, under the presidency of Mr. James Brand.

The SECRETARY (Mr. Thomas Blaikie) read the notice convening the meeting, and the report of the directors was taken as read.

The CHAIRMAN said: It is now my duty to make a few remarks to you, but I will detain you as little as possible. I think it may be convenient to say a word as I go along on the different heads alluded to in the report. First, as to capital, we have expended during the year £53,604. This has been spent as follows:—£26,378 in the London business, £13,326 on instruments distributed all over the country earning royalties, and £14,000 in stations worked by ourselves, such as Bristol, Southampton, Brighton, Ipswich, Norwich, and various places in South Wales which have not yet been made over to subsidiary companies. These companies are, however, in course of formation, and when completed will repay us the whole of our outlay in accordance with the arrangement already adopted with other companies we have formed. Meantime, they are doing very well, and have become valuable adjuncts to our business. You will have noted with pleasure that, with the above expenditure of £53,600, our revenue has increased £27,500, while our working expenses show an increase of only £5,500. I think also that you will feel that we are now grappling in earnest with the important matter of depreciation, although we are still without reliable data on which to form our calculations. We have written off over £15,000 this year. The dividend speaks for itself, and I hope you are satisfied. You may think that we might have squeezed out a little more, but our business is still in its infancy, and we never know what surprise may be in store for us, and so we think it much better to make up a good reserve account. We have therefore decided to add £10,000 to our reserve, and carry forward £5,000. This will make, with reserve, against depreciation, over £60,000, which I consider getting towards a substantial amount. As regards the progress of our business, we should have liked it to have been more rapid, but on the whole we must not complain, looking at the generally depressed state of trade all over the kingdom. This has caused the withdrawal of some of our subscribers, and no doubt prevented others from joining our exchanges. During the whole of this year, also, another company has been doing its best to prevent the public from joining our system by offering to give them exchange facilities for £10 instead of £20; but for all this, we have been able to fill up vacancies caused by removals, and to show a very substantial increase, as shown in our revenue account. Then, as to relations with the General Post Office, we have alluded rather fully to this subject in our report, and since that I have been again in communication with the Postmaster-General, who has pledged himself personally to take all our matters in hand, and I hope with a real wish to remedy our grievances so far as is consistent with his duties. I have in this matter to thank many Members of Parliament who have interested themselves in telephone matters on behalf of their constituencies and the public. We have had a very busy and eventful year. We fully advised you of what had been done in the first six months in our circular of the 12th February last. Since then, I am sorry to say, we have been rather busy with law, and we have won two or three important actions against infringers, which has greatly strengthened our hands. We have also had law forced upon us by the Wandsworth Board of Works and the authorities at Bristol, who took proceedings against us in the matter of our overhead wires in their districts. We don't blame them for taking this course, but we were bound to defend our position, and the result has been this: In the Wandsworth case, which was tried first, Mr. Justice Stephen, while deciding that our wires there were not a source of danger or a nuisance to the streets, decided against us that we were technically trespassers on the property of the Board. This would have left matters in a very unsatisfactory state, and we accordingly went to the Court of Appeal, who gave judgment unanimously in our favour. The effect of this is that the authorities must be able to show fairly that danger exists before our wires can be meddled with. The result of this decision has been that negotiations have been entered into, which we hope and expect will lead to a friendly and reasonable settlement in other cases. So far as this goes it is sufficient for the present. The telephone companies, carrying out their business as they do in the interest of themselves and the public, are of course most anxious to meet every requirement of the authorities—not only for the safety of the public, but also to avoid rousing even their susceptibilities. We have already done a great deal to minimise all possible danger by rearranging in every possible case our scattered wires, and running in their stead single cables containing not less than twenty wires. These cables are suspended to strong wires from pole to pole, and also by treble wires in the heart of the cable, so that it is almost impossible that they can fall. On these cables have been expended large sums of money during the last twelve months, and this greatly accounts for the heavy outlay on capital account, while we have only as yet received a very small advantage from them. I think, however, you will find the benefit of them in future balance-sheets. We quite agree with all thoughtful people that matters cannot rest where they are, and to this end we have used every effort to pass through Parliament a Bill for the proper regulation of overhead wires by a competent central authority, such, for instance, as the Board of Trade. We would gladly put all our wires under ground, but as I pointed out at our last meeting, this is for the moment simply impossible. Indeed, notwithstanding a letter that appeared last week in the *Pall Mall Gazette*, I don't think we have yet sufficient experience to prove that an exchange system on a really large scale can practically be worked underground—at any rate, in a city like London. The expense is so enormous, and, as I said at our last meeting, the crowded occupation of our central thoroughfares is so great that they cannot be used for fresh undertakings, especially in view of the wires for the electric light, which must be put underground if they are put anywhere. With regard to trunk wires connecting our exchanges in different towns, I am very sorry I cannot tell of much progress. The position taken up by the General Post Office is so difficult and impracticable that we have found it useless to struggle on with it, and preferred to do almost nothing and wait the result of our present negotiations than commence this branch of our business on the lines now laid down by the Postmaster-General. We hope these negotiations will come to a satisfactory issue, which would immediately result in an immense development of telephonic business, and I believe without doing any injury to the telegraph revenue of the Post Office. With regard to our Bill in Parliament for the regulation of overhead wires, while the Government were not indisposed to go into the whole question, they would not allow us to press forward a Bill on our own account, or introduce a Bill of their own while litigation was pending with regard to the present powers of the local authorities in the matter. No other point occurs to me, but I shall be pleased to answer any question, and, in the meantime, let me congratulate you and myself on meeting for the first time in our new building, which is a standing monument of our substantial advance in prosperity. You can see for youselves how quiet and secluded it is in the very heart of this busy city, and, therefore, how suitable for our business in every way. In conclusion, I must tell you that I have not words at my command to express to our managing director, Mr. Joseph B. Morgan, the grateful acknowledgments we would wish to offer to him for his untiring devotion and self-sacrifice in the interests of us all, and for his invaluable services in the promotion of the use of the telephone. One word more. Mr. Morgan's efforts and all our efforts would have been of no avail had he not had at his disposal the entire devotion of a staff of assistants whose hearts and brains were entirely wrapped up in this enterprise. And I take this opportunity to thank them heartily. And last, but not least, let me thank your legal advisers, Mr. Winterbotham and Mr. Crisp. They have not only given us their own most valuable services, but they have been successful in obtaining for you in all our contests the aid of four of the most eminent counsel at the bar, who have never for one moment left us in the lurch or neglected your interests; and although we have had to pay large sums of money for legal assistance, every shilling has been well spent and honestly earned. I will now conclude by moving the following resolution:—"That the report and accounts be received and adopted, and that a dividend for the half year ending April 30, 1884, of 5s. 6d., free of income tax, per fully paid £5 share (part paid shares receiving in proportion) be now declared."

The DEPUTY CHAIRMAN (Mr. J. S. Forbes) seconded the motion, which, he said, he felt sure would be received with unanimity. He had very few words by which to supplement the speech of the chairman, who, however, had left him a few plums. "The proof of the pudding is in the eating," and what they were very much concerned in nowadays was that there should be no mistake as to whether their implement was an implement of great social and commerical value. There seemed in some minds some doubt of that even now, as one could hardly imagine—if the view which they themselves took of the matter was correct—that a great public department could be indifferent to it, or could be blinded to the fact that the public sooner or later would insist upon having the use of a means so valuable as the telephone. Besides the department referred to there was a great deal of misunderstanding about it. He was very often surprised to find men of the greatest intelligence who never appeared to have considered how they could add to their own comfort and the efficiency of the way in which they conducted their affairs by the use of the Company's instrument. That morning he had been in a great establishment, and to his surprise he found no telephone about the place. He said to the manager, "I do not understand you. You have your relations all over London, all over your own establishment, and you use enormous time, and undergo great discomfort in doing that which you could with the telephone do instantly with perfect ease." He himself was able to sit in Victoria-street, and with the use of the telephone he could make all his business dovetail in; and, in fact, what used to be a difficult thing was now perfectly easy and certain by the use of the telephone. Persons could communicate with each other and arrange business, and get business conducted in the course of an hour or so, while under the old system it took the whole day. Their progress, notwitstanding the immense advantages they offered, was not as rapid as they could wish, but still it was very substantial. Four years was a very short time for an enterprise of that kind to be in existence. In the first year, ending with April, 1881, they had 914 subscribers on exchange lines, and there were 943,000 calls; while in 1884 the number of subscribers had increased to 3,350, and the calls to 6,120,000. As to private lines, in the first year there were only 186, and that number had since grown to 715, and grown notwithstanding all the difficulties they had had put in their way by a department which he respectfully suggested ought to know better—the Post office, with their restrictions, their obstructions, and general absurdities—and by the difficult questions that had had to be overcome as to way leaves, and so on. There were a good many fallacies about on that subject. The shareholders had heard what had taken place, and how, when they grappled with the questions of danger and disadvantage, all that was said went off into air. What were the facts? He had been surprised to read the other day, in the *Pall Mall Gazette*, an article by

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Silvanus Thompson, who was an electrical engineer and a philosopher. He did know whether that gentleman had done what Mr. Morgan had done. Mr. Morgan knew what the difficulties were in practice, and they were without any record of the dangers which Mr. Thompson wrote about. The Company, too, had had some experience, and Mr. Thompson felt that. He knew that he could not found upon experience so far, and therefore had gone into "bogey." He said—although nothing had happened in the past four or five years—if you wait long enough you will have such a crop of accidents that will send all your wires underground. The experience the Company had was, moreover, not confined to this country. It required a great deal of tact and determination to overcome the difficulties and prejudices they had encountered. He had been to America, and although he did not run amuck in favour of American institutions generally, America was a go-a-head country, and it put one to the blush that such a country as ours, with such cities as London, Liverpool, and Manchester, should be so far behind. A report had just been put into his hands of the American Bell Telephone Company for last year. They had given the figures relating to the United Company, and he might state that the American company had the astounding number of 123,000 subscribers, the increase in the number for the year ended last January being 25,000. Of course the American company covered more ground than the United Company, but still let them consider for a moment, 123,000 subscribers on one exchange in America in one company! What did that mean? Why, that their American friends had appreciated the enormous advantage of this invention, and were not obstructed as this Company had been by the State. That was the reason for it. Was it worth while listening to them *versus* Silvanus Thompson, or the philosophers, and alarmists, and people who did not trouble to arrive at conclusions based on facts? The report of the American company said:—"It is common to see in the public papers round statements that the wires ought to be at once ordered underground. In this matter we and our associates have the strongest motives for wishing to get the wires underground as far and as soon as it can be done, without destroying the efficiency of the service. The plant would be more permanent and no longer liable to interference from municipal authorities or individuals, or destruction from storms; and its maintenance would be cheaper and easier. There were the motives. But although short trunk lines work fairly well beneath the surface, as shown in Boston and elsewhere, in the present state of the art it is impracticable to put the bulk of the wires underground without interfering seriously with facilities upon which the public are now getting to depend. Conversation over long lines (those reaching the suburbs even) is difficult and often impossible to those who are connected through the underground cables. Were the electrical difficulties overcome, a mixed system would still be needed, as the distribution of the wires would probably have to be overhead, as well as the wires in the more sparsely covered parts of a city. Overhead cables are rapidly coming into use, and as they can be taken on small fixtures, and carry many wires in a small compass, while attracting far less notice than the open wire system, besides being safer in case of storm or fire, their adoption is a step in the right direction, and will go far to remedy the evils of the present overhead system." They themselves had arrived at precisely the same conclusions. Cables were used in place of overhead wires where they could do so; but the real point was this, if they were to have a great public convenience it was sure to be attended with some slight drawback, some possible drawback; and they could not have the telephone, any more than railways, steamboats, and cabs, and obtain the enormous advantages thus secured without some possible drawback. What they had to do was to look before they leaped, and not to be alarmed into doing anything owing to the crotchets of people who aired their views rather easily in the Press. He concluded by endorsing the chairman's eulogies on Mr. Morgan and the staff.

The CHAIRMAN put the motion, which was carried unanimously. In reply to questions he said that they would give ample notice when they required to make a call on the new shares. At present they did not want the money. The shares of the Lancashire and Cheshire Company were saleable to-day at 27s. As to the National Company, they had paid one per cent. dividend, but he did not know what the shares of the Company were worth. If the enterprise in which they were engaged succeeded as they expected, the shares in the National Company, the Northern District Company, and the Telephone Company of Ireland would one day—and not at a very distant date—represent their nominal value.

The retiring directors, Mr. James Brand and Mr. J. S. Forbes, and the auditors, Messrs. Quilter, Ball, and Co., and Messrs. Price, Waterhouse, and Co., were next unanimously re-elected.

The CHAIRMAN, in reply to a question, stated that the agreement with the Globe Company was not yet finished. They had the power to make the agreement, and he did not know that it would be first submitted for the ratification of the shareholders.

Mr. E. H. GALSWORTHY thought it would be unwise to discuss the question, as it was really not before the meeting; and, moreover, he thought the matter might be very well left in the hands of the directors. The meeting then terminated in the usual manner.

TRAFFIC RECEIPTS FOR JUNE, 1884.

COMPANIES.	June, 1884.	June, 1883.	Increase.	Decrease.
Cuba Submarine	3,150	2,688	462	—
Direct Spanish Telegraph	1,345	1,556	—	211
Eastern Extension	31,787	34,307	—	2,520
Great Northern	22,960	—	—	—
West Coast of America	3,615	—	—	—

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	Closing Prices. July 16.		Business Done Week Ending July 16. Highest.	Lowest.
Anglo-American	33,	34	33⅛	33
Do. Preferred	58,	59	58¾	57
Do. Deferred	7½,	7¾	7½	—
Brazilian Submarine	9⅞,	10⅛	10	9 15-16
Cuba	9¾,	10¼	10	—
Do. Preference	16½,	17½	—	—
Direct Spanish	4½,	5	—	—
Do. Preference	14¼,	14¾	—	—
Direct United States Cable	9⅞,	10⅛	10	9¾
Eastern Telegraph	11,	11¼	11 13-16	11⅝ x d.
Do. 6 per Cent. Preference	13½,	14	13⅞	13¾
Do. 5 per Cent. Debentures, 1899	103,	107	—	—
Eastern Extension	11¼,	11½	11½	11 1-16 x d
German Union	9¼,	9¾	—	—
Globe Telegraph and Trust	6⅝,	6⅞	6 13-16	6⅝
Do. Preference	12¼,	12¾	12⅝	12½
Great Northern	13½,	13¾	13¾	—
Indo-European	30,	31	30½	—
Mediterranean Extension	1¼,	1¾	—	—
Do. Preference	2,	3	—	—
Reuter's	8,	8½	—	—
Submarine	155,	160	158	—
West India and Panama	⅝,	⅞	13-16	—
Do. 1st Preference	6,	6½	—	—
Western Brazilian	5⅛,	5⅝	5¼	5 3-16
Western Union 7 per Cent. 1st Mortgage	123,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	106	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	3-16,	5-16	—	—
Oriental	⅛,	⅜	—	—
United Telephone	9½,	10	10⅛	9⅝

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1½,	1¾	1⅝	1 9-16
Do. (fully paid)	3,	3½	3¼	—
Hammond Light (£3 15s. paid)	⅜,	⅝	½	—
Eastern Electric (£4 paid)	—	—	—	—
Swan	⅜,	⅝	½	—
Maxim-Weston	⅛,	¼	⅛	—

MISCELLANEOUS.

Telegraph Construction	32,	33	32½	32
India Rubber, Gutta Percha, and Telegraph Works	22,	23	22¾	—

TELEGRAPH CONSTRUCTION and MAINTENANCE COMPANY (Limited).

NOTICE is hereby given that the TRANSFER BOOKS of this Company will be CLOSED from the 14th to the 22nd inst., both days inclusive, preparatory to the payment of an ad interim dividend of 12s. per share to all shareholders on the Register on the 14th inst.

By order,
E. DICKENS, Secretary.

38, Old Broad-street, E.C., July 11th, 1884.

CLEVEDON, SOMERSET.

The CLEVEDON LOCAL BOARD of HEALTH are desirous of receiving TENDERS for the PUBLIC LIGHTING of their District for the period of NINE MONTHS, commencing 15th August next, either by Electric Light, Oil, or otherwise. Also for REPAIRING, Painting, Cleaning, Lighting, and Extinguishing the Public Lamps (about 186).

The lamps to be lit at sunset and extinguished at midnight.

Tenders to be sent to me on or before the 29th instant.

The Board do not bind themselves to accept the lowest or any Tender.

HY. C. FRY, Clerk.

Clevedon, 10th July, 1884.

WANTED at once, an intelligent MAN, experienced in manufacture of electric light carbons, to take charge of a small Carbon Plant in a factory near London, S.E. district. State experience and wages required.—Address replies, "Coppered Carbon," care of *Electrician*, 1, Salisbury-court, Fleet-street, London.

THE ADVERTISER seeks a SITUATION as PHYSICAL DEMONSTRATOR. Has had five years' experience at two colleges. Reason for leaving the present position is the rearrangement of classes. Good practical knowledge of electrical testing. Good testimonials. Address, "Ohm's Law," *The Electrician* Office, 1, Salisbury-court, Fleet-street, E.C.

Just Published. Price One Shilling. Second Edition, Enlarged, with 25 Illustrations.

MAGNETO AND DYNAMO ELECTRIC MACHINES.

By J. ANGELO FAHIE, C.E., Member of the Society of Telegraph Engineers and Electricians.

London: E. and F. N. SPON, 16, Charing Cross. New York: 35, Murray Street.

"ELECTRICIANS" WANTED.—Any one who wishes to SELL *THE ELECTRICIAN* of January and February, 1882; April 9, 1882; May 6, 1882; March 25, 1882; August 26, 1882; and February 10, 1883, call at 52, York-terrace, Regent's Park.

FOR SALE, SIEMENS, BURGIN, and GRAMME DYNAMO MACHINES and ARC LAMPS. Little used. Offered at low prices.—Mackay and Mess, C.A., 104, Commercial-street, Dundee.

AUTUMN ELECTRIC LIGHTING.—FOR SALE, ENGINES, DYNAMOS (BRUSH), LAMPS, &c.—Apply Richard Fyfe, 2, Walbrook, E.C.

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NOTES.

UNITED ASBESTOS COMPANY.—We notice that this company has reduced its capital to £110,000.

ELECTRIC LIGHTING IN NEW YORK.—It is said that the extension of electric lighting in New York has put out no less than 3,000 gas lamps.

LIGHTNING CONDUCTORS.—The current number of the *Edinburgh Review* contains an article on this subject, which we hope to notice at length in a future issue.

EASTERN EXTENSION TELEGRAPH COMPANY.—The coupon of this company's Six per Cent. Debentures, due August 1st, will be paid on and after that date at the Consolidated Bank, Threadneedle-street.

PYRAMID ELECTRIC COMPANY.—Creditors of this company should send in their names and particulars of their claims before the 15th August to the liquidators, Messrs. Foster and Brain, Whitecroft, near Lydney, Gloucestershire.

DIVIDEND.—The directors of Edwin Fox and Co. (Limited), of the Magnetic Telegraph Wire Works, West Ferry-road, E., have declared an interim dividend at the rate of 10 per cent. per annum for the half year ended 30th June last.

SOUTH KENSINGTON MUTUAL ELECTRIC LIGHTING COMPANY.—Creditors of this company should send in their names and particulars of debts to Mr. G. A. Cape, 8, Old Jewry, E.C., the official liquidator, before the 15th August.

THE TREE OF LIBERTY AT STRASBURG.—A heavy thunderstorm broke over Strasburg on Thursday, the 17th inst., during which the lightning felled to the ground the tall poplar planted in 1792 to commemorate the advent of the Republic.

ANGLO-AMERICAN TELEGRAPH COMPANY.—This company, after placing £37,500 to the renewal fund, have declared an interim dividend for the past quarter of 17s. 6d. per cent. on the Ordinary, and 35s. per cent. on the Preferred stock.

KELWAY'S ELECTRIC LOG SYNDICATE.—The 12th of August has been fixed as the last day for receiving the names of creditors of this company, and particulars of their claims. Mr. E. J. Morris, of 58, Lombard-street, E.C., is the liquidator.

VOLTAMETERS.—After experimenting with various liquids, M. Guillaume finds that the distance between the electrodes, which has but little influence in a sulphate of copper voltameter, has considerable effect in a sensibly pure water voltameter.

PATENT EXAMINERS.—An examination for the post of assistant examiners in the Patent Office will be held shortly. Applications will be received up to 29th August, and all particulars can be had of the secretary, Civil Service Commission, London, S,W.

THE TELEGRAPH IN SIAM.—*The Times* correspondent at Bangkok says:—"The construction of a telegraph line has been sanctioned, and will be pushed on and completed in the next dry season, from Bangkok to Zimmay, and thence afterwards to Burmah."

ELECTRIC LIGHT MATERIAL WANTED.—Tenders are invited for the supply of dynamos and lamps for various installations of incandescent lamps. Tenders are to be forwarded, before 2nd of August, to Mr. W. C. Martin, electrical engineer, Commercial-street, Dundee.

ACCIDENT FROM LIGHTNING.—On Wednesday, the 16th inst., during a storm, a house in the village of Chantemerle, Geneva, was struck by lightning and set on fire. There being no water available to extinguish the flames the fire spread, and the whole village was reduced to ashes.

ELECTRIC LIGHTING IN WORKS.—The new British Iron Company have recently increased the number of arc lamps in their works at Corngreves, near Cradley. It will be remembered that several Weston lamps were put up in these works some time since by the Maxim-Weston Company.

ELECTRIC LIGHTING IN VIENNA.—It is stated that the Office of Works for the City of Vienna has approved of a specification for the lighting of portions of the new Rathhaus with electric lamps. It is to receive the sanction of the magistrates and common council, and then tenders will be invited.

SUBMARINE TELEGRAPH COMPANY.—The accounts of this company for the half year ending June 30, show a balance, subject to audit, which enables the directors, after adding 15 per cent. of the gross receipts to the reserve fund, to recommend a dividend at the rate of 13 per cent. per annum.

THE NEW ATLANTIC CABLE.—*The Times* correspondent at Philadelphia telegraphs, under date July 21, as follows:—"In a telegram from Dover Bay, New Hampshire, it is stated that the laying of the new cable has been completed, and that messages are successfully passing between Dover Bay and Waterville in Ireland."

ELECTRIC LIGHTING ON RIVER STEAMERS.—The Hudson River steamer St. John has, says an American contemporary, been furnished with Edison electric lamps on quarterdeck, in kitchen, and in dining room, as an experiment. The success has been sufficient to lead to the extension of the system to all parts of the steamer, and it will also be placed on the Drew, of the same line.

ELECTRIC LIGHT WORK IN 1883.—We have received a copy of a pamphlet by M. Ph. Delahaye, a well-known French engineer, entitled "L' Industrie de l' Eclairage Electrique en 1883." It is a reprint of a paper read by M. Delahaye at the recent Congress of the Société Technique de l' Industrie du Gaz held in Paris, and contains some interesting figures as to the relative cost of gas and electric lighting.

FAURE ELECTRIC ACCUMULATOR COMPANY.—The creditors of this company should send in their names and claims before the 14th August to the liquidators at the office of Messrs. Cooper Brothers and Co., of 14, George-street, Mansion House, E.C. Vice-Chancellor Sir J. Bacon has made an order for the winding up to be conducted under the supervision of the Court of Chancery.

THE MONARCH CABLE STEAMER.—On Wednesday week this cable ship completed the repair of the Forth cable, which had been damaged close to the Burntisland shore. On Wednesday last she laid a cable between Barra and the mainland of Orkney, thus connecting the principal southern islands and fishing stations of Orkney with Kirkwall. After replacing one of the Shetland cables, broken last winter, she was to proceed to the Isle of Man.

THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.—At the meeting of this company held this week, a report of which appears in another column, the chairman, Sir Daniel Gooch, stated that they had manufactured 4,322 miles of cable in the last six months, and laid over 4,800 miles. They were hard at work, he said, endeavouring to complete the lighting of Paddington station, and hoped to have all ready by November or December.

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ELECTRIC LIGHTING AT WALHAM GREEN.—At the fête of the Butchers' Charitable Institute at Walham Green on the 15th inst. the grounds, ball marquee, and tents were beautifully illuminated with six arc lights and fifteen Woodhouse-Rawson incandescent lamps of 20 candle-power. The steadiness of the arc lights was commented upon by all present. The work was carried out by Messrs. Woodhouse and Rawson, and the installation consisted of an eight horse-power portable engine, with separate dynamo machine for arc and incandescent circuits.

EARTHQUAKES.—On the night of the 19th inst. an earthquake was felt at Agram. It lasted four seconds, and was accompanied by subterranean rumblings. No damage was done.—A telegram from Rome, dated July 23, says: A strong shock of earthquake, accompanied by loud subterranean rumblings, was felt at twenty minutes to one o'clock this morning at Forio, in the island of Ischia. No damage was done, but in a telegram to the *Stampa* it is stated that it is impossible to describe the consternation of the inhabitants, who anticipate a renewal of last year's catastrophe.

CRICKET MATCH.—The annual cricket match between teams of the Manchester and North Lancashire District of the Lancashire and Cheshire Telephonic Exchange Company was played at Ewood Park, Blackburn, on Saturday, July 12, and after a very pleasant and enjoyable game ended in a victory for North Lancashire District by the narrow majority of six runs. Afterwards the members of the Manchester team were entertained at the White Bull Hotel, when a very pleasant evening was spent, during which several members of the two districts gave a sample of their musical vocal powers.

HAIL.—M. Colladon, of Geneva, has observed some remarkable movements on the part of particles of sleet, which, remaining motionless for one or two seconds after their fall, were afterwards projected to a height of ·25m. or ·30m., as if by an impulse imparted by the earth. This curious phenomenon was noticed in two falls of sleet at Geneva, one on the 19th January, 1881, the other in March, 1883, and a third time during a fall of hail at Hauts-Crêts, at the summit of the hill of Cologney. Mr. Colladon quotes two other similar observations of M. Melsens, published in *La Lumière Electrique* for 26th February, 1881.

REIS'S TELEPHONE.—At the last meeting of the New York Electrical Society Professor VanderWeyde, the president, exhibited copies of the Reis telephonic apparatus, made from the original designs of 1860. The exhibition included working models of the various receivers and transmitters of Reis, with improvements of his own. The professor stated that he gave an exhibition of these instruments as long ago as January 7, 1869, in that very room, at which time the persons present thought they could distinguish articulate sounds, although he then thought it impossible. All that he imagined it to be capable of doing was the transmission of musical sound.

ELECTRIC LIGHTING IN DETROIT.—The city authorities of Detroit, Michigan, having executed a contract with the Brush Electric Light Company to light the city by means of the tower system, two citizens, stockholders in the Excelsior Electric Light Company, have filed a bill in Chancery, and applied for an injunction to restrain the city from carrying out the contract, on the ground that proposals were not received and the contract not awarded in accordance with the terms of the charter. The parties to the suit also ask that the Brush Company be enjoined from erecting towers in the public streets and places. No preliminary injunction was asked for, and the case will be tried on its merits.

RAIN TO ORDER.—A French electrician, says a contemporary, suggests the following method for producing rain as required. His plan is to send up one or more balloons freighted with panclastite or some other equally explosive compound. They are to be connected with a battery on the ground by means of a fine wire, and when they attain the necessary altitude—that is, when they enter the cloud-zone—the spark is to be transmitted. The detonation will follow, and a refreshing shower will be the result. We noticed in these columns not so very long since that a Victorian colonist had laid plans before the Government of that colony for producing the same happy result in identically the same way. If the idea ever becomes a practical reality we may find political parties making use of it to disperse open-air meetings of their opponents. What an effect might not a heavy downpour have had upon the Franchise meeting in Hyde Park on Monday, for instance?

SHIP LIGHTING.—The latest addition to the fleet of the Glasgow and Steam Shipping Company is the "Thistle," which has been built by Messrs. Henderson and Co., Partick, Glasgow, and lighted, to the specifications of Professor Jamieson, by the Pilsen Electric Light Company, of London, with 41 Gatehouse lamps, each of 20 candle-power actual. The ship is wired in four distinct circuits, all being controlled from one switchboard in the engine room. The lamps in the saloon are fitted with switch holders, so that any lamp may be turned out at pleasure. The machine is compound wound, of the Pilsen-Schuckert type, manufactured by the company, having an armature of the hoop-iron construction, and only requiring a speed of 450 revolutions to give the necessary current, which is 25·4 amperes, or ·62 per lamp. The engine is a Westinghouse high speed, built by Messrs. Alley and M'Lellan, of Glasgow, and fitted by them to the same bed plate as the dynamo. We understand the work has been carried out to the entire satisfaction of the owners and the consulting electrician, and reflects great credit on the company.

ELECTRIC LIGHTING IN HULL.—At a meeting of the Lighting Committee of the Hull Town Council, held on Thursday week, the town clerk reported that on the 10th inst. the council passed a resolution rescinding the contract with Messrs. Siemens for lighting the Old Town with electricity from the 28th inst. He had given the necessary notice to Messrs. Siemens, and requested them to make arrangements for removing all their plant and machinery, and had received a letter in reply informing him that the necessary instructions would be given for the removal of the plant. Some discussion arose amongst the members of the committee as to whether tenders should not be invited from other firms for electric lighting, and many were by no means pleased to learn that the Works Committee had that morning passed a resolution to light the Old Town with Sugg's lamps. In the end it was resolved, on the motion of Mr. Hall, seconded by Mr. Grindell, that the committee be instructed to give the borough engineer instructions to obtain tenders for, and report to the committee on, the best means of lighting the public lamps and the Town Hall within the area at present lighted with or without electricity.

THE ELECTRO-CHEMICAL EQUIVALENT OF SILVER.—In the *Journal de Physique* for July M. Mascart has an article in which he gives an account of recent experiments undertaken by him to determine the weight of silver deposited or dissolved during one second by a unit of current. Some few months ago he arrived at the conclusion that the quantity was 11·24 m.g. Kohlrausch gives 11·36, and Lord Rayleigh 11·19. Since these determinations F. and W. Kohlrausch by a fresh series of experiments have found it to be 11·183, and Lord

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Rayleigh has recently, March, 1884, made it 11·18. Accordingly, M. Mascart thought it necessary to re-verify his calculations, and acknowledges that he was deceived. Without going into his calculations, we may say that he now gives his result as 11·156 mg. The chemical action of one ampere per second, or of one coulomb, will therefore be, says M. Mascart:—

According to Kohlrausch...		1·1183 mg. of silver dissolved.		
Ditto	Rayleigh ...	1·118	ditto	ditto
Ditto	Mascart	1·1156	ditto	ditto

Lord Rayleigh's method of determination and the results obtained will be found described at p. 607 of our last volume, *Electrician*, May 10, 1884.

The Turks and the Telegraph.—The Turkish Government exercises a very wide discretion as to what may and may not be despatched or received per telegraph wire in its dominions. Thus *The Times* correspondent at Constantinople states that "For some months past any telegram containing direct or indirect reference to Egyptian affairs has been considered objectionable, and even the Queen's Speech at the opening of Parliament was suppressed for that reason. At present this oppressive kind of censure can be patiently borne, because newspapers and letters are received through the foreign post-offices, and telegrams can be easily sent through the same channels to some telegraph office beyond the frontier. But if the postal communication falls into the hands of the Turkish authorities, this means of softening the rigours of the present absurd system will be destroyed, and foreigners in Turkey may be condemned to isolation almost as complete as if they lived in Central Africa." The Turks are evidently of one mind with the Boer, whose opinion was that telegraphs were a nuisance. If the news were worth having, he opined that it would keep, and if bad he thought it had better not come at all.

The Electric Light for War Purposes.—On Thursday night a series of trials were to be carried out at Aldershot to test the applicability of the electric light to the purposes of searching for the wounded. Lord Hartington was to be present, together with a number of the Army Medical Department and representatives of the War Office. A parade of the garrison was ordered for 9 p.m., when the experiments were to begin. The apparatus employed was to consist of Messrs. Sautter, Lemonnier and Co.'s portable electric light tackle, with engine, dynamo, and lamp on one carriage, very similar to that illustrated in *The Electrician* for July 1, 1882, Vol. IX., p. 153. This portable apparatus is used in the French army to a considerable extent. It will be remembered that at the time of the Vienna Exhibition the Austrian Government carried out a series of experiments of identical character with those made on Thursday night at Aldershot, the results being only partially satisfactory. Sautter and Lemonnier's apparatus was used on this occasion also. A short notice of these experiments will be found in our issue for Oct. 27, 1883, p. 555. We shall give further details of the Aldershot trials in our next issue.

The Telephone in Plymouth.—The *Western Morning News*, of the 17th inst., has some very hard things to say of Mr. Fawcett concerning the telephone business in Plymouth. Our readers are well acquainted with our view of the question. Here is the view taken by our western contemporary:—"Much was hoped from placing so able and enlightened a statesman as Mr. Fawcett at the head of the Post Office, and proportionately great is the disappointment at finding that in the matter of the telephone and telephone exchanges there is nothing but procrastination, repression, and narrowness, resulting in financial failure and public inconvenience. In Plymouth, Devonport, and Stonehouse, three years ago, there were 150 residents, each of whom could speak to the other through a telephone exchange. But official pique on the part of the Post Office put a stop to this, and established a so-called Post Office Exchange. The number of members has never exceeded forty-six; it has now fallen back to forty-two; and several other subscribers have given notice to leave unless the numbers are so increased as to make the exchange really worthy of the name. Plymouth is but a sample of nearly every other town where the Post Office monopoly has taken effect and Post Office Exchanges have been instituted. But for the Postmaster-General's veto a real and useful exchange might be established in the three towns next week, at a subscription far less than that which the Post Office demands."

Recording the Vibrations of a Tuning Fork.—The exact determination of the rate of vibration of a tuning fork by means of the siren has heretofore been attended with errors resulting from imperfections of the recording gear and difficulty of maintaining and counting the beats of the two tones. These errors have been sought to be removed by obtaining autographic records of the rate of the siren and of the difference between this rate and that of the fork. The experimenter, while obtaining these results, being freed from the necessity of even counting the beats, no personal element enters into the observation, and the records, being permanent, can be studied at leisure. The apparatus with which these results are obtained is described in the *American Journal of Science*, the method employed being the following:—A strip of chemically prepared paper, which rests on a metal wheel, being drawn by clockwork under three platinum pens placed in electric circuits, three simultaneous electro-chemical records are obtained. One of these is a line of dots made at the rate of one a second, by a chronometer placed in the circuit of the same battery with one of the pens. The second is a row of dots made by a closing of the same circuit by a siren once in each revolution, while singing nearly in unison with the fork. The third is a row of dots made by the closing of the circuit of a second battery, once for each beat of the fork and siren. It thus results that from the same strip of paper can be counted the number of revolutions made by the siren in any number of seconds (which gives the number of impulses produced by the siren) and the number of beats in the same time, which is the difference between the number of shocks imparted to the air by the siren and the number imparted by the fork. The record being made without throwing any work upon the fork, the rate of vibration of the unconstrained fork results.

A Peroxide of Lead Cell.—In his excellent report to the United States Government on "Submarine Mines," Colonel Abbot makes the following remarks on the peroxide of lead cell: "In 1876, Charles T. Chester introduced in New York, under the name of 'magazine battery,' the De la Rive peroxide of lead cell. This element is remarkable for its high electromotive force, and, among single fluid cells, for its constancy of action. The depolarising substance is expensive; and, as put upon the market, it contained traces of nitric acid, which proved destructive to the zincs. Notwithstanding the latter defect, the cell exhibited incontestable merits. Two cells were tested. In both the negative plate consisted of a carbon plate embedded in peroxide of lead contained in a porous cup. This cup was 3 inches in diameter and 5·5 inches high. The positive plate was the common Leclanché cylinder of zinc, ½in. in diameter and 7in. long. They were placed in a cylindrical glass cell, 4in. in diameter and 6in. high, half filled with fluid,

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which for one cell was dilute sulphuric acid (1 part of acid to 14 parts of water), and for the other cell a saturated solution of sal-ammoniac. The internal resistance of the former at the first closing of the circuit was 1·7 ohm, and at the end of the trial 7·5 ohms. These cells were allowed to stand for a few days without closing the circuit, and the change in electromotive force was noted by Law's method as follows: Feb. 19, 1876, acid cell, 2·305 volts; sal-ammoniac cell, 1·800 volts. Feb. 24, acid cell, 2·128 volts; sal-ammoniac cell, 1·664 volts. Feb. 25, acid cell, 2·057 volts; sal ammoniac cell, 1·689 volts. Feb. 26, acid cell, 1·994 volts; sal-ammoniac cell, 1·642 volts. They were then placed at work continuously for five days. After a rest of two days, and a re-amalgamation of the zincs which had begun to suffer, the circuit was again closed, the electromotive force being 1·580 and 1·490 volts respectively. At the end of the thirty-third day both cells were exhausted, new zincs and fluids being required. About a minute after the circuit was finally broken, the electromotive force of the acid cell was ·471 volt, and of the other, ·803 volt.

The Late Abbe Moigno.—The late Abbé Moigno, whose death we announced in last week's issue, was buried at Saint Denis, Paris, in the presence of a large number of theologians and scientists, on the 17th inst. The journal, *Les Mondes*, with which he was so long and intimately connected, publishes a portrait of him in its issue of the 19th inst., together with a long biographical notice, from which we make the following extracts. The abbé, whose full name was Francois Napoleon Marie Moigno, was born at Guéméné-sur-Scorf (Morbihan), on the 15th April, 1804, and died 13th July, 1884. His family was noble; but his father, who was called Moigno de Villebeau, abandoned his title after the first revolution. M. Moigno began his education at the College de Pontivy, and terminated it with the Jesuits of Sainte-Anne-d'Auray. He wrote his first article in 1829; and about this time we find him making friends with the men of science of the day, amongst whom were Ampère, Arago, Biot, Becquerel, Dumas, and Chevreul. In 1845, the *Epoque*, a journal then just started by Emile de Girardin, sent the Abbé Moigno on a scientific mission through Europe. In his travels he visited Italy, Austria, Germany, and England, and made lasting friendships with such men as Secchi, Rossi, Clausius, Helmholtz, Humboldt, Maxwell, Thomson, Siemens, Tyndall, and others. After several years of travel he returned to Paris, only to find that petty jealousies had risen up between him and his jesuitical brethren, and that he was regarded with disfavour by them. In 1849 he published his "Traité de Télégraphie Electrique," the first work of its kind which appeared in France. In 1850 the kind of ban under which he had been placed was somewhat relaxed, and he was appointed second almoner at the Louis-le-Grand Lycée. Here he remained three years, during which he contributed many scientific articles to the press of the day. In February, 1851, M. de Montfort started a paper called *La Lumière*, which was the organ of the Société Héliographique of Paris, and to this paper the Abbé was a frequent contributor. It lived but a short time, however, being given up in the following October. In May, 1852, M. de Montfort founded the *Cosmos*, and made the Abbé Moigno editor. The *Cosmos* was soon afterwards carried on under the new name of *Les Mondes*, by which it is still known. For more than thirty years the Abbé gave all his hardest and best work to this paper. Although his troubles with his ecclesiastical superiors were the source of continual worry to him for several years, and although his income was scanty, he never abandoned his *Cosmos*. Among the benefits which the Abbé conferred on his brother scientists was to translate into French the works of Tyndall on heat, light, and sound. In 1870 M. Moigno was residing at Saint Germain des Près, when the Prussians were besieging Paris. One evening, as he entered his library with a candle in his hand, a shell struck the house, fell in the library, and burst into a hundred pieces. The Abbé did not flinch, but quickly relighting his candle, which had been extinguished, calmly surveyed the damage that had been done. The writer of the obituary notice we are abstracting states that he has a fragment of this shell in his possession. Later on, under the Government of M'Mahon, Abbé Moigno was nominated Canon of Saint Denis, and in this retreat he continued to write and to work up to the very last.

Atmospheric Electricity.—Prof. Edlund, of the Royal Academy of Sciences of Sweden, some time ago (1878) published a memoir in which he endeavoured to prove that the unipolar induction produced by the rotation of the earth upon its axis is the principal cause of the electricity of the air. He has recently returned to this subject, *Phil. Mag. Supplement* for June, and we make the following extract from his paper: "If the air were an absolute non-conductor, the production of a difference is electric tenison between the air at the surface of the earth and the air of the upper regions would be totally impossible. But this is only the case when the air is perfectly dry. If, on the contrary, it is saturated with moisture, it forms a comparatively good conductor of electricity, as is proved, amongst other things, by the impossibility of maintaining an electric charge, however feeble, on a body surrounded by air, of which the relative humidity is considerable. Thus, when the air is moist, the difference of tenison may soon attain the limits mentioned; but when the electricity has reached a certain distance from the equatorial plane, it is conveyed by the horizontal force of unipolar induction towards more elevated latitudes—towards the north in the northern hemisphere, and towards the south in the southern hemisphere. The force of unipolar induction is always the same, where not subject to small variations produced by those of the terrestrial magnetism; but the conductibility of the air depends upon the changes which take place in its humidity. The result is a perpetual variation in the electric condition of the air. If the electric tension, at any point under a high latitude, becomes greater than that which corresponds to the vertical component of unipolar induction at the same point (which is possible, since electricity is brought there from points situated in lower latitudes), part of the electricity will flow from the air to the earth. As is shown in the preceding memoir, this takes place especially in the zone surrounding the magnetic poles where we meet with the aurora borealis. If the air is highly saturated with moisture, and if this saturation extends through some considerable space, the air will become more highly electric than when the air is relatively dry; consequently the air will generally be greater in winter than in summer, after cooling at night. The air usually attains its maximum relative humidity in the early hours of the day, diminishing in the morning as the air becomes heated, attaining its minimum soon after noon, and then increasing in intensity towards the evening. All this is in complete agreement with well-known observations. On the other hand it appears more difficult to explain the minimum of aërial electricity, which, according to certain observations, is produced in the course of the night, at least if we do not admit that in those regions where this minimum has been observed, local causes have produced a disturbing effect. It is much to be regretted that observations upon the electricity of the air are too few and imperfect to permit of a more detailed comparison between theory and

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experiment. The quantity of electricity which, in accordance with the preceding, should exist in the earth's atmosphere in consequence of the unipolar induction of the earth is sufficient, in my opinion, to account for the indications of the electric condition of the air, given under normal conditions by the instruments employed for this purpose."

THE TELEPHONE IN EDINBURGH.—A capital article describing the growth of the telephone in Edinburgh appeared in the *Courant* for the 17th inst. The number of subscribers to the Central Exchange now reaches 290, many of whom reside in Leith, Newhaven, Trinity, and Granton, which lie just outside Edinburgh. The writer of the article has compiled the following statistics as to calls, &c.:—"These 290 subscribers," he says, "make amongst themselves, on an average, 1,480 communications per day. Every subscriber therefore employs his telephone say five times a day, or 1,825 times during the year. As each communication consists of at least one question and answer, this represents 3,650 messages or telelogues—as telephonic despatches have come to be called—per subscriber per year. The rate of subscription being £15 per annum, the cost of each message is rather more than nine-tenths of a penny. Looked at from another point of view, the telephone costs each subscriber rather more than 9¾d. per day, or 5s. 9d. per week. The wages of this novel servant are therefore not in excess of that of an ordinary message boy. The company, moreover, supplies a second line to any subscriber at a cost of £10 per annum, thus materially reducing the expense of telephonic communications where, for instance, a place of business and a residence are both put in connection with the exchange. The utility of the telephone in Edinburgh has lately been greatly increased by the opening of a trunk line to Glasgow, by means of which any subscriber to the Edinburgh Exchange may be connected with any of the subscribers—and they number about 700—to the Glasgow Exchange. The additional charge for this service varies from £50 to £25 per annum, according to the facilities required. The whole of this rental, owing to the conditions imposed by the Post Office, is paid over to the Government, the telephone company working the service free of charge for the benefit of its subscribers. As trunk wires also exist from Glasgow to Paisley and Greenock, Edinburgh subscribers may likewise communicate with the subscribers to the Paisley and Greenock Exchanges upon paying the Government charge. It is an interesting fact that the trunk wire between Edinburgh and Glasgow is the longest telephonic line in the United Kingdom. The communications passing over it sometimes number 50 in one day. The number of wires owned by the Telephone Company in Edinburgh is necessarily very large, the total length exceeding 236 miles. A great improvement has lately taken place in the character of the wire used for overhead purposes. Originally the wires were of iron, weighing 211lb. to the mile; now they are of phosphor-bronze, and weigh only 37lb. to the mile. As a span of wire—*i. e.*, the distance between two supports rarely exceeds 150 yards, and is generally much less, the greatest weight which can fall into the street at once is only about 3lb. This weight of 3lb. again cannot all fall at the same spot, but must be distributed over say 150 yards of ground. Overhouse wires, however, have now become so numerous that great difficulty is experienced in finding room for the new ones which are constantly being required. To meet this difficulty, and to avoid impairing the amenity of the town, the Telephone Company have now an application before the Town Council for permission to lay the wires on one of their most crowded routes underground. Should this application be granted, as it doubtless will be, advantage will be taken of the opportunity to re-arrange the wires, so as to obtain from them better results than is possible at present."

OVERHEAD WIRES.—In the House of Commons, on Tuesday, Sir H. Tyler gave notice that on Thursday he would ask the Home Secretary whether, having regard to the number of overhead wires in the City, and the danger arising therefrom during thunderstorms and high winds, he would take some means to deal with the question.—Sir A. Gordon asked whether Her Majesty's Government would next year introduce a Bill to give to the local authorities of the metropolis and other towns such a power of inspection and control over the construction and maintenance of overhead telegraphic wires as would tend to protect the public using the streets from the dangers incident to such aërial fabrics.—Mr. G. Russell said it was impossible for the Government to undertake to make a statement with regard to the Bills to be brought in next session, but there would probably be some advantage in the appointment of a Select Committee, and the matter would be considered.—According to the *Daily Telegraph*, unless the Government take the initiative in the matter, some private members intend next session to bring in a Bill giving the local authorities of the metropolis and other towns power of inspection and control over the construction and maintenance of overhead wires.—Mr. J. Russell Endean writes to *The Times* of Thursday as follows: "After the judgments recently pronounced in the Wandsworth and in the Bristol cases on the power of local authorities to control the wires of telegraph and telephone companies, the St. Marylebone vestry withdrew the action it had commenced against the Globe Telephone Company for an injunction, on the ground that, for all purposes desired by the Government, the vestry considers the local authorities have now ascertained in the law courts, after 'a well-considered and unanimous judgment,' that there are no existing legal powers by which they can exercise such control. The united vestries of St. Marylebone and St. James, Westminster, have therefore resolved to memorialise the Government to introduce at the earliest possible moment a Bill by which all control over the wires of telegraph and telephone companies through the streets of the capital shall be placed in the hands of the local authorities; and, further, these vestries have invited the other vestries and district boards of London to adopt the same course. When the deputation on this subject recently waited on the President of the Local Government Board he hinted that if legislation were proved to be necessary the Government would not hesitate to legislate, but the power of control would most probably be placed in the hands of some central authority, such as the Metropolitan Board of Works, and would not be intrusted to the local authorities. Sir, I venture to think such a deprivation of control as this implies will not be to deal justly with these authorities. At present all matters connected with the streets and thoroughfares are administered by vestries and district boards, and why these wires should be made an exception I am at a loss to conceive. I would therefore suggest that all wires in London in the public thoroughfares should be controlled by the local authorities of the parishes through which they are conveyed; that, on any question or dispute arising between the parish authority and a company, either party should have power to appeal to the Metropolitan Board of Works for settlement of the matter in dispute, and that the decision of the said Board shall be final and shall not admit of any further appeal. This would prevent useless expenditure in law courts, would meet every requirement that could possibly arise, and would thus confer upon the local authorities the power with which they have just given such conclusive evidence they are fully competent to deal."

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INCANDESCENT LIGHTING.

BY T. H. SEYMOUR HAWKER.

(CONTINUED FROM PAGE 208.)

The resistance of a copper conductor increases about ·38 per cent. per degree Centigrade increase of temperature. Therefore, in cases of great current density—that is to say, when the ratio of current to sectional area is considerable—the calculation of the resistance of the conductor, *while carrying a current C*, has to be made from the formula

$$R_2 = \phi \cdot \frac{l}{s} \cdot (1 + a\,T \pm b\,T^2).$$

Here ϕ is the specific resistance of the material, l length (a convenient submultiple of the whole), s sectional area, and T the ultimate temperature in accordance with the formula given in the last article (on p. 208). The constants a and b depend on the material, and for pure copper and most other metals are equal to ·00383 and ·00000126 respectively. The purity of the metal has a deal to do with the value of these constants, however, and Matthieson states that the percentage of decrement in the conducting power of an impure metal between 0° C. and 100° C. is to that of a pure metal, between the same limits, as the ratio of their conducting powers at 100° C.

The "percentage conductivity" here referred to is very essential in all calculations involving resistance. It is the ratio of the reciprocal of the measured resistance of a sample to the reciprocal of the calculated resistance of a conductor of pure copper of similar dimensions. The highness of this percentage determines the value of the copper for conducting purposes, and it is apparent, therefore, that a deal depends on the quality of the metal used. A standard should indeed be fixed upon, and samples of each portion tendered for the contract subjected to a verificatory test.

The next important ruling factor in determining size of cables is that of cost of possession as compared with the value of energy wasted.

It has been frequently pointed out that the greatest economy is attained when the cost of possessing a conductor —that is to say, interest on first cost, depreciation, and redemption—is equal to the money value of the energy wasted in uselessly heating its resistance.

This can be very conveniently formulated and used to determine the weight of copper per unit length which it is advisable to employ. Let k be the prime cost of the conductor of resistance, R, which is to carry an average current, C, and γ the fraction representing the percentage of this value allowable for annual cost. Then with λ as the cost of a year horse-power, and θ the fraction of a year that the conductor is in use

$$k\gamma = \lambda\theta \cdot \frac{C^2 R}{7{\cdot}459 + 10^9}$$

From this we can get the necessary resistance R of the conductor to fulfil these conditions as being

$$R = 7{\cdot}459 + 10^9 k\gamma / C^2 \lambda\theta.$$

By taking the resistance in terms of weight and length, and restricting the previous equation to a small length of l centimetres of the conductor, we can obtain a more convenient formula for the weight of the conductor per length l.

$$W = \frac{\lambda\,\theta\,C^2\,l^2\,\rho\,\phi}{7{\cdot}459 \times 10^9\,k\,\gamma} \quad . \quad . \quad . \quad \text{in C.-G.-S.}$$

Here ρ is the specific gravity of the copper used and ϕ the specific resistance per c.c. when heated by the average current C according to the previous formulation. It will be seen from this that the size of a conductor should be considerably dependent on such local conditions as the price of coal, or at all events on the cost of power in the special case. Such formulæ as this will be of great service when electric lighting becomes more universal, and large central stations and dynamos of economy and vast power allow plenty of margin in the energy supply. At present, however, the majority of machines demand rather unreasonable concessions to their many weaknesses, and when the cost of energy becomes a point for criticism the leads may be safely left to some rule depending on the minimum allowable efficiency of the circuit, and the attention turned to the more prolific sources of waste nearer home. Compare the loss by air-heating in machines with Gramme and Pacinotti type of armatures with that in the ironless Ferranti, and the range for one description of improvement will be apparent. In some armatures of the Pacinotti type the working temperature is some 120° F. above the surrounding air, or 10,000 odd foot-lbs. in each lb. of the iron ring, subject to dissipation by radiation and convection.

A very useful method of finding the size of any part of an electric light circuit is the one I have referred to above, namely, that the energy wasted on any part of the circuit must be the same percentage of the total energy flow through it as the total circuit waste is to the total energy in circuit. This at once points to the necessary resistance, but there is considerable difficulty in formulating the operation.

It has been already pointed out that the E.M.F. should be the same at the terminals of all the lamps. The margin of E.M.F. which must be supplied by the generator to allow for resistance of leads, must therefore be just expended in driving the lamp current up to each individual lamp; or, in other words, the resistance from the generator through any lamp and back to the generator must be constant in all cases; or if r = hot resistance of lamp, c = lamp current, and E the E.M.F. at generator terminals, then this constant resistance will be $R_o = (E - c\,r)/c$, the amount of excess of E over $c\,r$—the lamp E.M.F.—being determined beforehand by the theoretical circuit efficiency.

Now this resistance R_o will be made up of the lamp leads, sub-mains, and mains, and we have merely to determine the proportions in which we can distribute the spare E.M.F., $E - c\,r$, so as to give the best economy in copper. This must of course depend in a measure on the prices of different sizes of cable, but the most logical method seems to be to distribute the resistances in inverse proportion to the currents, that is to say, when the total resistance of leads through each lamp is $R_o = \frac{E}{c}$, the section of each lead will need to be, if the conductor be graded in n sizes between generator and lamps, $= s = \phi\,l\,c\,n/E$.

We can advantageously combine these methods into a suitable system for any particular work, but it is convenient to have formulæ for their values in terms of any of the portions which are known. Let us take α, β, γ as the resistances respectively of mains, sub-mains, and lamp leads. Then the sum of these we know "by construction" $l = \alpha + \beta + \gamma = \frac{1}{n-1} L$, the aggregate resistance of lamps being L and $n = \frac{L + l}{L}$.

The resistance of the mains α must be sufficiently low to carry the whole current c, while leaving sufficient E.M.F. for β and γ. That is to say, if c_1 and c_2 be the currents in the latter

$$\alpha = \frac{l\,c - (\beta\,c_1 + \gamma\,c_2)}{c}.$$

The current c_2 in γ being very small, the current needed for one or two lamps only, it is easy to assign a practicable value to it, such that too high sections shall not be necessitated in the other portions or too great temperature attained. Moveover, as the lengths may vary in different lamps, too small a section is liable to create an inequality of E.M.F. distribution. We can then treat γ as known.

Again, the same considerations affect both mains and submains, the difference being in degree only, varying as the current. We can therefore formulate β in terms of α, as $\beta = \frac{\alpha\,c_1}{c}$ which value inserted in the preceding equation gives us as the value of α

$$\alpha = \frac{c\,l - \gamma}{c - c_1},$$

and from this the value of β can be obtained as

$$\beta = l - (\alpha + \gamma).$$

From these resistances the values of sectional area or

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weight per given length of a material of specific resistance ϕ and gravity ρ can be deduced by the formulæ (for C.-G.-S.)

$$W = \frac{\phi \rho l^2}{R} \qquad S = \sqrt{\frac{\phi W}{R \rho}}.$$

It should be remembered that the E.M.F. is generally to be considered as a fixed quantity. In increasing the length of any lead or main, therefore, its resistance must be kept constant by a proportionate increase of sectional area.

The "jointing" and piecing together of different portions of a circuit has, unless most carefully performed, usually the effect of increasing the resistance. I shall refer to the operation of jointing in a future part of this paper devoted to the practical portion of the subject. I merely mention this now as forming, together with unavoidable accidental mechanical stresses in erection and fixing, and other sources of increase in circuit resistance, an argument in favour of the allowance of a margin of, say, five per cent. on calculated data. This is, of course, with reference to exceedingly low resistance circuits, where a variation of ·0001 of an ohm makes an appreciable difference, as in low resistance dynamos running on large installations of low E.M.F. lamps all in parallel.

(TO BE CONTINUED.)

A GALVANOMETER AND BATTERY TEST.

The comparison of electrostatic capacities by De Sauty's W. B. method is effected as follows:—

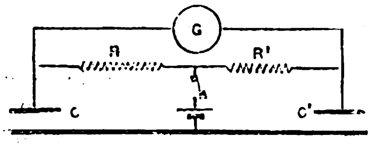

Fig. 1.

Where R and R′ are known and adjustable resistances, C a known and adjustable capacity, and C′ an unknown capacity. Then

$$R : R' :: C' : C, \text{ and } C' = \frac{R}{R'} C.$$

This test may be reversed, and by means of two known capacities and a known resistance, the value of an unknown resistance may be arrived at. Then if C, C′, and R be known and R′ unknown, once a balance has been obtained, one has

$$R' = \frac{C}{C'} R.$$

By developing the above facts, a convenient method is obtained for ascertaining the resistance of either battery or galvanometer. These two tests, it will be seen, bear a certain analogy to Mance's W.B. battery test, and to Thomson's W.B. galvanometer test.

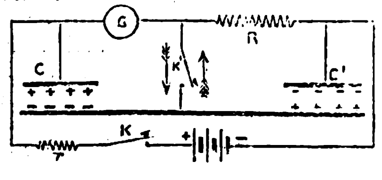

Fig. 2.—Galvanometer Test.

G = galvanometer of resistance unknown.

R = resistance known and adjustable.

r = convenient resistance inserted in battery circuit without influencing conditions of test.

C and C′ = two condensers, or one divided condenser of known and adjustable capacity.

Any one, or all, of the three values R, C, and C′ may be made adjustable.

Then the unknown resistance of G may be arrived at as follows:—Battery with instruments having been connected up, as shown in Fig. 2, K is depressed, a certain deflection, d, being thus obtained on G. R, C, and C′ are now adjusted until d remains undisturbed on the closing of K′. When this is the case,

$$G : R :: C' : C, \text{ and } G = R\frac{C'}{C}.$$

In practice it is convenient to make C and C′ equal, and to adjust R until a balance be obtained. Then

$$G = R.$$

It will be found that if the balance be *out* one way or the other—if, for instance, R be higher than G, the closing of K′ following upon the depression of K, with its accompanying deflection

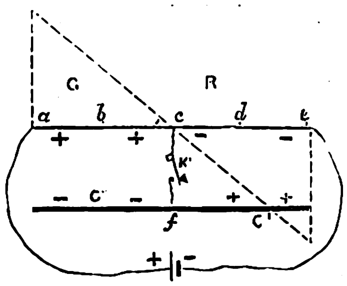

Fig. 3.

d, will cause a "*throw*" say to the right of the already deflected "*spot*." If, on the other hand, R be lower than G, the "*throw*" will be to the left of d, the "*spot*" in both cases immediately returning to position d. But when R = G, assuming that C = C′,

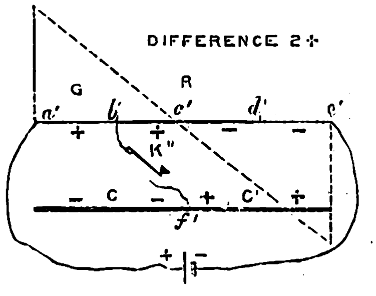

Fig. 4.

a balance is arrived at, and the closing of K′ in no way affects d, for the following reason:—

The closing of K′ completing, as it does, two inductive circuits, to both of which K′ is common—namely K′, G, and C

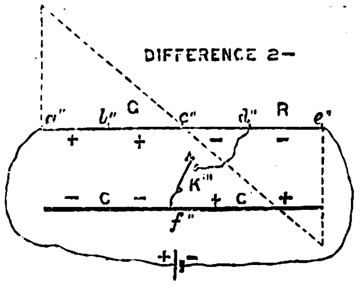

Fig. 5.

on one side, and K′ R, and C′ on the other, when a balance has been effected, that is to say when G : R :: C′ : C, K′ becomes attacked, so to speak, by two discharges, which being equal in potential, but contrary in direction, neutralise each other, and so in no way affect G. Whereas, when a balance does not exist, that is to say, when G is not to R :: C′ : C, one of the two discharges being of a higher potential than the other, the difference between the two is thus left un-neutralised, and is free to affect both inductive circuits, and thus to disturb G.

The direction of the consequent "*throw*" on G depends upon the *sign* of the discharge, which, in its turn, depends upon the nature of the adjustments of G, R, C, and C′. Assuming C

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and C′ to be equal, if R be higher than G, the above-mentioned difference would be, say, *positive*, and the "*throw*" on G, say, to the right of *d*. On the other hand, if R were lower than G, the reverse would happen.

Figs. 3, 4, and 5 illustrate the *rationale* of this galvanometer test under three different conditions of things:—

1. Where a balance has been made, and G = R;
2. Where a balance does not exist, and where R > G;
3. Where a balance does not exist, and where R < G.

In all three examples C = C′.

a b c and *c d e* represent G and R respectively;

C and C′ represent two equal condensers, or what is the same thing, one condenser equally divided.

Here G = R and C = C′; so G : R : : C′ : C.

The distribution of electricity consequent upon such an arrangement is shown by + and − signs.

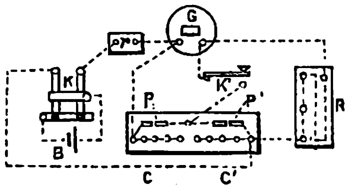

FIG. 6.

The closing of K′ connects points *c* and *f*, thereby not only forming two inductive circuits, but also producing two discharges in opposite directions, one neutralising the other. This neutralisation may be here represented by the equal number of + and − signs on either side of the points connected by K′. *a′ b′* and *b′ c′ d′ e′* = G and R respectively.

Here G = but $\frac{1}{3}$ R, whilst C = C′; so in this case a balance does not exist, and upon the closing of K″ and the consequent connecting of points *b′* and *f′*, one of the contrary discharges is at a higher potential than the other. So both inductive circuits are affected by the difference between these two potentials. In Fig. 4 this difference is represented by the two + *signs*, which are left un-neutralised on one side of points connected by K″.

This case is the reverse of Fig. 4.

Here G = 3 R, whilst C = C′, and the remaining un-neutralised *signs*, after closing of K‴ and consequent connection of points *d″* and *f″*, will be 2 −.

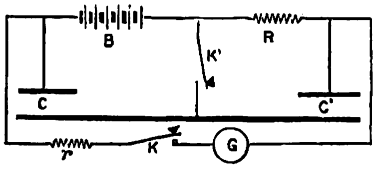

FIG. 7.

In Fig. 4, where R > G, the two inductive circuits, including the one containing G, are influenced by a discharge of 2 +.

In Fig. 5, where R < G, a discharge of 2 − is the disturbing agent.

So that in these two cases the "*throws*" on G are in opposite directions, and it is only when a balance exists, as in Fig. 3, that G remains undisturbed.

By the above method the writer has taken rapid tests of mirror galvanometers of a resistance ranging between 600$^{\omega}$ and 5,200$^{\omega}$. The results checked by ordinary bridge tests with a second galvanometer have proved correct within one or two units. For the testing of a mirror galvanometer of the "water," "dead beat," or ordinary "signalling" pattern, the only appliances necessary are an adjustable resistance and an office condenser, but when G is a sensitive testing galvanometer of the astatic pattern, an extra high resistance *r* (*vide* Fig. 2) inserted in the battery circuit becomes necessary for the producing of a convenient deflection within the limits of the scale.

It has been found requisite for both C and C′ to be short-circuited for an instant after each attempt at a balance, and before a fresh adjustment is made, in order to dissipate the residual charge.

The following shows the practical arrangement of the test:—

C and C′ an ordinary office condenser of say 20 micros, divided as convenient, each side being short-circuited at pleasure, at P and P′ (*vide* Fig. 6).

r extra resistance inserted if necessary, but in no way influencing conditions of test already explained.

B = convenient battery.
R = adjustable resistance.
G = galvanometer of unknown resistance.
K′ = make-and-break key. K battery key.

Battery Test.

By making G and B change places, the resistance of B may be calculated by the proportion—

$$B : R : : C' : C, \text{ or } B = R \frac{C'}{C},$$

a balance being obtained as before by adjusting R until no disturbance is noticed on G's deflected spot, when K′ is closed, *vide* Fig. 7.

If necessary for the obtaining of a convenient deflection, an extra resistance *r* may be inserted with G without altering conditions of test. A shunt also may be used on G.

E. RAYMOND BARKER, Madeira.

THE EDISON CENTRAL STATION IN MILAN.

During the past year great progress has been made in Italy towards the commercial introduction of the Edison system, the centre of activity being the enterprising city of Milan.

In August, 1882, the "Comitato Edison," a committee representing the leading banks of Milan, delegated Professor Colombo, of the Milan Polytechnic, to investigate the Edison Central Station system.

After visiting the stations in London and New York it was decided to undertake the installation of a central station plant for 3,000 lights, and towards the middle of October the construction of the station was begun. The station, which is a handsome three-story brick structure, was erected in accordance with the plans of Professor Colombo on the site of the old Teatro Santa Rodegonda, near the celebrated Duomo. The installation of the dynamos and the electrical plant was directed by Mr. John W. Lieb, formerly electrician of the Edison Central Station in New York. The first lights were supplied from the station in June, 1883, and they have been in constant operation ever since without any interruption. The generating plant then consisted of four Edison dynamos, type C, with a capacity of 1,200 lights each. Two of the dynamos are driven by Porter-Allen engines, and two have engines constructed by Messrs. Armington and Sims. These engines are connected direct, and run at 350 revolutions per minute, the Porter-Allen engines having cylinders 11 3-16 diameter and 16in. stroke; the Armington and Sims engines being 14½ diameter and 13in. stroke. The steam was furnished by four Babcock and Wilcox boilers of 160 horse-power each. In August, 1883, as a result of the action taken by the Municipality of Milan, the Edison Company closed a contract with the administrative board of the La Scala Theatre, for lighting it from their central station. It was therefore decided to increase the capacity of the station by the addition of two more dynamos and an additional boiler, making in all six dynamos and five boilers.

On the 22nd of September the Manzoni Theatre was added to the list of consumers, and it has been lighted every night since that date without the least accident or inconvenience. The installation at this theatre, while insignificant compared with that at La Scala, is yet of considerable importance, the total number of lamps supplied being about 400. The whole theatre, stage, vestibule, corridors, dressing rooms, &c., are lighted by Edison lamps, gas having been entirely excluded. The intensity of the lights in the auditorium and on the stage

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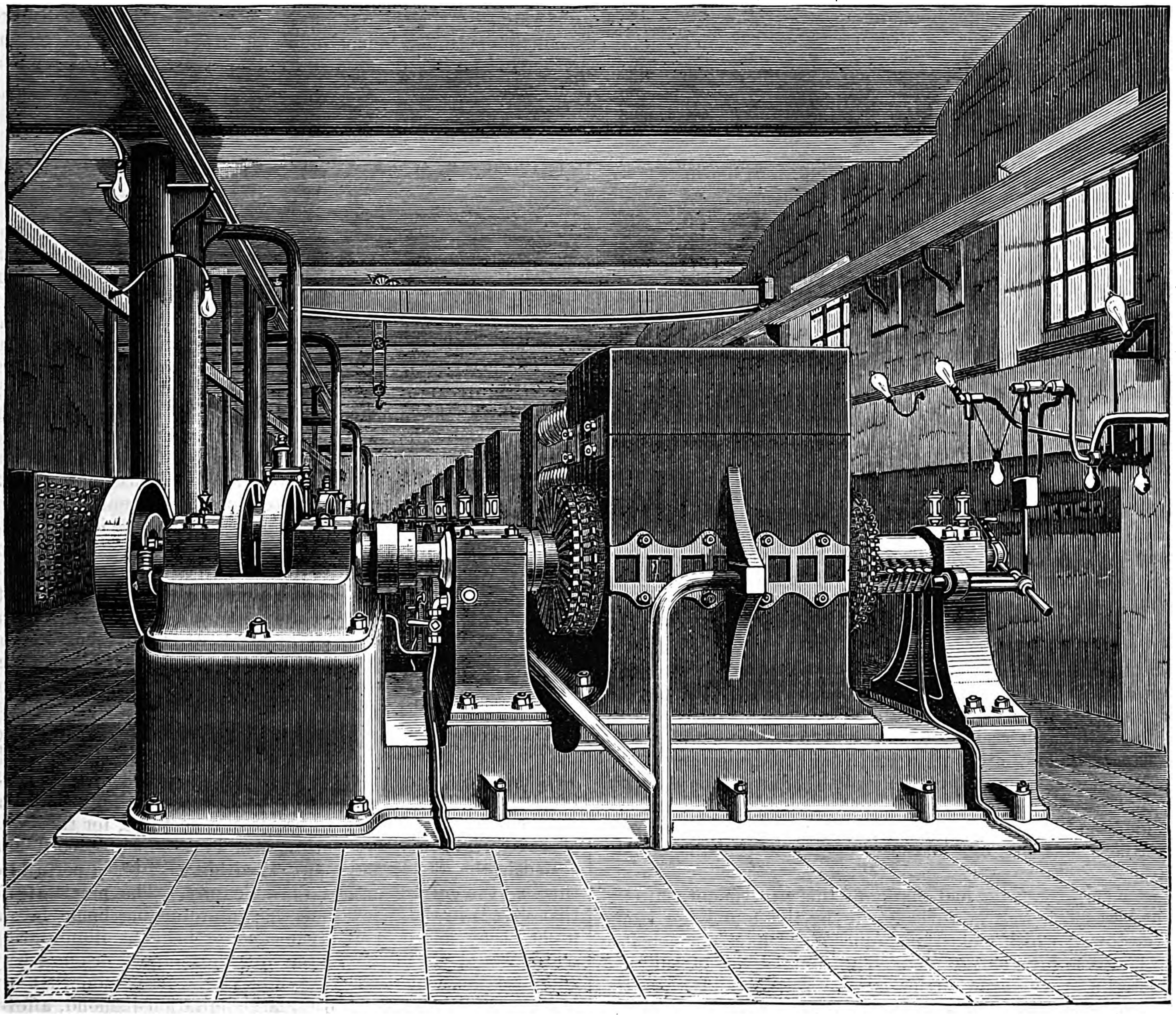
is controlled by five regulators, giving any desired degree of illumination, from full 16 candle-power to total darkness.

Without doubt, the largest permanent installation of the electric light in the world is that just completed and now in operation at the Great Teatro a La Scala, and it may be of interest to present some details of this colossal installation. The total number of lamps is nearly 2,500, distributed as follows:—The stage, which is the largest in the world, requires for its illumination 1,000 lamps; the auditorium and orchestra, 400; vestibule, corridors, foyer, and boxes, 500; the remaining 600 are distributed among the offices, dressing rooms, and the different stage service apartments. The stage lights and those of the grand chandelier are controlled by sixteen regulators. The resistance bobbins are made from light T iron, faced with wood, upon which strands of galvanised iron wire are wound for interpolating resistances in the lamp circuits. The regulators are distributed as follows:—Eight for the overhead traverses, three for the side lights, two for the footlights, and three for the chandelier. Each resistance frame occupies a space of 2 metres high, 1 metre long, and half a metre wide. The lights supplied through these sixteen regulators can be manipulated separately or simultaneously by means of a common shaft carrying level gears, which engage with gears on the separate switches. In all, 1,316 lamps are controlled by regulators, all of type A (16 candles), and they are distributed as follows:—408 in the overhead traverses, 264 for the side lights, 80 on the reflectors, 120 for the movable stage footlights, and 100 in the fixed footlights. The grand chandelier alone contains 344 lamps, divided among three circuits, each circuit having its own regulator. To provide colour effects, the traverses footlights and sidelights are provided with blue and red glass globes, making it possible to instantly change from blue to red or white. The regulators are grouped in a room upon the stage, situated so as to command a good view, and from this regulator room all of the stage circuits are under full control. All the lamps in the theatre to the number of 2,500 are supplied from four services branching from the general underground network of the central station system, the theatre itself being situated some 450 metres from the central station. The construction of this vast installation was done under the direction of the general manager, Professor Colombo, by Mr. Lieb, electrician of the Italian Edison Company, and Mr. Bertini, of the electrical staff. The underground conductors of the district traverse the principal streets in the vicinty of the Piazza del Duomo, and they have at the present time a total length of nearly five kilometres. The most distant consumer is situated about 500 metres from the station. The total number of lamps now being supplied from the station is about 3,500, which number will be increased to 4,000 by the end of January.



Edison Central Lighting Station at Milan.

It is the intention of the company to increase the number of dynamos to ten during the coming summer, and to extend the network of conductors so as to be able to meet the supply of consumers out of reach of the present plant.

The contracts with consumers are made at a variable price per unit, depending upon the consumption. The charge is

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made up of two parts, a constant for each lamp installed corresponding to the interest on investment, depreciation, &c., and a variable charge per lamp-hour corresponding to the cost of coal, attendance, &c. Upon this basis, proposed by Professor Colombo, the large consumers have the Edison light at a price equal to or even less than the cost of gas, while the small consumers who use the current but a small number of hours per day pay from 10 to 20 per cent. more than the cost of gas.

Since the 26th December the La Scala Theatre has been lighted regularly five nights per week without the least interruption or accident of any kind. Three dynamos at the Central Station supply the current to the theatre and all the other installations. The Italian press is very enthusiastic in praising the great success of this installation, unique for the difficulties overcome, and its vast proportions.

ELECTRIC LIGHT AT TURIN.

The following account of the electric light at Turin is translated from an article which appeared in one of the leading Italian newspapers:—

"It is impossible to keep our eyes shut any longer to the brilliant and numerous applications of electricity for illumination. The electric light as a source of illumination is undoubtedly destined to supersede gas. The incomparable superiority of this system of illumination over all others that are known to us up to the present time is just now beginning to be appreciated by us, and whilst remembering that it may be still further perfected by study and careful research, the experiment at Turin makes us now entirely in favour of lighting the establishments and streets of the town by this new method of illumination. At the instigation of G. Doll, Esq., director of the establishment Gruber, the large square of Turin is lighted magnificently by the electric light, to the general satisfaction and pleasure of the inhabitants. The Crompton dynamo machines, driven by two turbines, were placed in the weaving mills of Messrs. Gruber. Swan incandescent lamps, sixteen of 16 candle-power, were used to light the square, while Crompton lamps of a power of 6,000 candles each were affixed to the four corners of the tower of the municipal buildings. The light given by these lamps was most intense, white, and constant, and has been likened to a splendid full moon. Turin now appears to have shaken off the apathy and laziness which seemed to have grown upon it, and one may almost prognosticate that it is the future Manchester of Italy, which name was applied to Biella by Cavour. The plentiful supply of water-power favours immensely its development. It is understood that if Turin adopts the electric light to illuminate its streets and private houses, Biella will probably follow suit."

Mr. Kempster, who had charge of this experiment, says:—"The best effect was, however, made by the four large lamps on the tower, which looked magnificent. I have never before seen lamps so high as 120 feet. The consequence of this altitude is a very even light on the square, and that the rays are projected an immense distance. It is easy to read large type at a distance of about 600 metres (about 666ft.), and the reflection is thrown by the lamps all round the valley, a distance of ten or twelve miles. The Grand Square at Alexandria was illuminated when the King of Italy visited that city for the purpose of unveiling the statue recently erected to the lamented Batazzi, the illustrious Italian statesman."

Writing home at the date of the installation, Mr. Kempster says:—"The first night of lighting up we had not time to finish some joints in the wire at the bottom of some lamp-posts; we therefore joined it temporarily. A gendarme was standing with others at the bottom of one of the posts, and with natural officiousness he took hold of one of the wires, remarking to the bystanders that he could always stand a good deal of electricity. As he did not feel anything very particular he took hold with both hands, gave a little pull, then a great one, when lo and behold! the wire parted between his hands and the entire current rushed though his unlucky body. The unfortunate fellow was thrown a distance of over two yards, and fell senseless to the ground. He was taken to a neighbouring house, but was some time before he recovered his senses, and then could not speak. For a long time his arms and hands were paralysed, and two black marks on the palms of his hands showed where the current had entered. He had to keep his bed for several days, and is now undergoing fourteen days' imprisonment for touching the wires. I do not think he will try again how much electricity he can stand.

"On the mountains around the peasants are gathering olives in the evening when the lamps are burning, and a landowner who lives several miles away says that he has no need now to set watch for thieves, as the strong light would effectually prevent their coming. The night we first lit up the mayor sent a band of music to serenade Mr. Doll on his arrival home at midnight."

ELECTRIC JEWELLERY AND PORTABLE LAMPS.

In the early days of his electrical career that fertile inventor, Gustave Trouvé, of Paris, made some small jewels that executed various rapid movements at the pleasure of the wearer. Flies, butterflies, and humming birds flapped their wings; a lilliputian rabbit beat a microscopic drum, a death's head rolled its eyes and ground its teeth, &c., the movement being caused by a small electro-magnet, the current of which was supplied by a hermetically sealed battery carried in the pocket. But as the serious applications of electricity claimed more and more of M. Trouvé's attention, he could no longer superintend the construction of these scientific toys, and it was difficult to find workmen who would give the necessary care to their manufacture. Turning his attention more recently to electric lighting by incandescence M. Trouvé conceived the idea of enclosing minute lamps in various articles of jewellery, the imitation gems of which are so cut as to intensify the rays of light projected through them. We should not devote so much space to this subject, but that we see more than one useful and practical application of the idea; and, indeed, M. Trouvé has himself brought out a development of the principle which is calculated to render great service in entering an explosive atmosphere, while keeping both hands at liberty.

The accompanying illustration (Fig. 1) shows various articles of jewellery, each containing a small incandescent lamp, a full-sized sketch of which is appended. No. 1 is a hair-pin; 2 and 3, breast-pins; 4, the head of a cane; 5, a diadem for tiara; and 6, a large gem, intended to be set in a necklace, for theatrical effects. The leads are enclosed in a small supple cord concealed in the dress; and a switch within easy reach permits of turning the current on or off at pleasure. The practical use that we see in these jewels is that, in returning home late at night, they afford a ready means of brilliant illumination, which would aid in the finding of a lost object, or one's way, and also the way to the keyhole, &c. It is said that the walking stick, provided with a large imitation diamond, affords sufficient light to read a newspaper by. If set with, say, a white gem on one side and a red one on the other, it may be used for signalling to a distance, while the switch would enable a communication to be carried on by means of the Morse alphabet.

The neck of the lamp is luted into a small metal collar, so that a new lamp may be readily inserted in case one should break (Fig. 2). The battery, which is shown partly in section, was last year brought by M. Moncel before the Academy of Science, Paris. The ebonite case A (Fig. 3) is divided by compartments into three cells, two-thirds of their space containing a super-saturated solution of bichromate of potash. The cover B, also of ebonite, carries the elements D and D^1, and is attached to the case by two india rubber bands, E and E^1, a sheet of india rubber, C, forming a tight joint. To prevent any possibility of the liquid escaping, the whole is enclosed in

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two thin ebonite covers, F and G, fitting after the manner of a cigar case. H and H¹ are the binding screws for the conducting wires. The duration of incandescence varies nearly in the ratio of the capacity of the battery. The smallest, shown full size in the cut, is capable of maintaining illumination for twenty or twenty-five minutes; while one twice the size, which may be carried by a belt attached to the outside cover, will maintain it for an hour. For theatrical effects of short duration, the size No. 3 will maintain incandescence in eight lamps at once; indeed, as many as twenty-five have been kept going at the same time. The battery can also be recharged in a few minutes by renewing the solution.

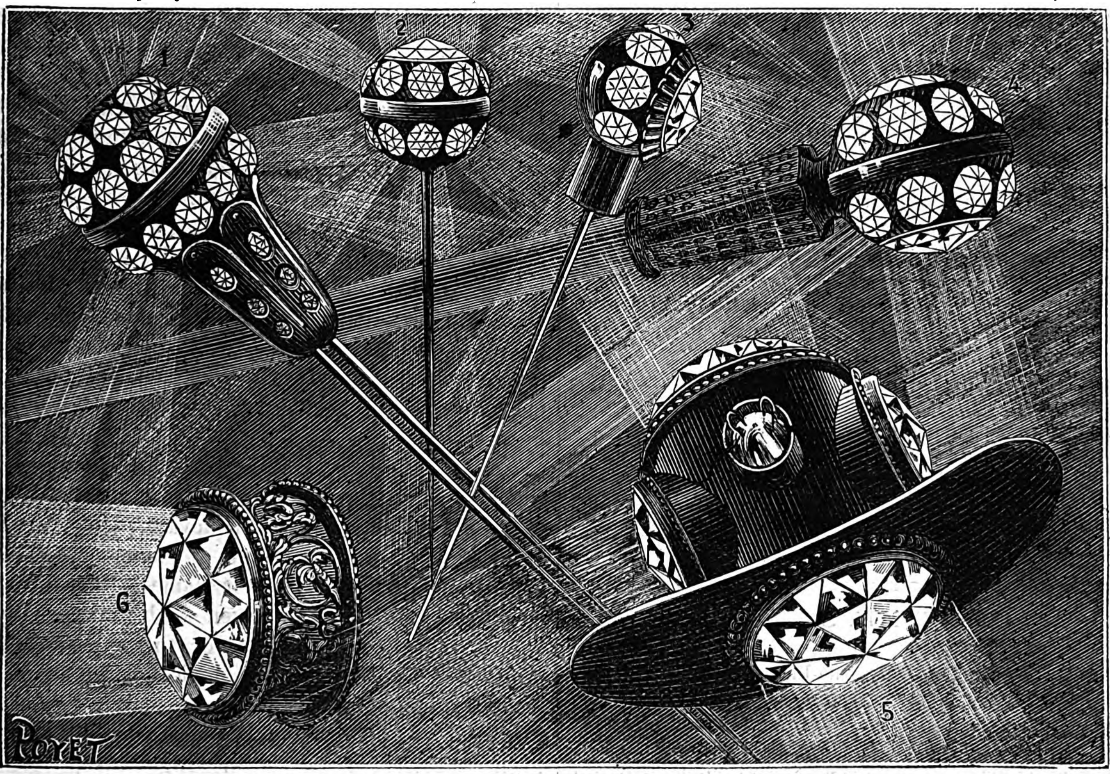

Fig. 1.—Collection of Trouvé's Electric Jewellery.

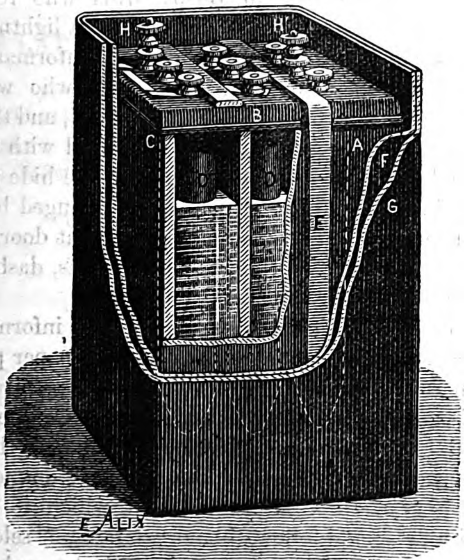

Fig. 3.—Trouvé's Battery.

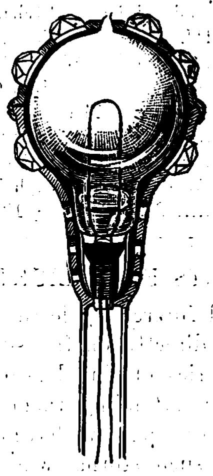

Fig. 2.—Trouvé's Scarf-pin.

The latest and most practical application of this system is that by means of which an *employé* of the Compagnie Parisienne du Goz is provided with one of these lamps attached to his head, so as to leave both arms at liberty for stopping a leak in a gas pipe without fear of igniting the explosive mixture of air and escaping gas. The battery is carried by a belt at his side; and the rays of light, intensified by a lens, are directed on to the work. His mate is provided with a modification resembling a miner's safety lamp; but both have the advantage of being self-contained, and not dependent on long conductors from a fixed battery. Both forms have been used successfully by the Paris Gas Company for about a year, the inside of gas-holders having been frequently inspected in this way. They are used by more than one manufacturer of dyes prepared with very volatile fluids, such as ether, benzine, sulphate of carbon, &c. Having recently been brought before the notice of the Société de Physique, these lamps are now adopted at the Paris Observatory for taking the readings of various instruments during the hours of darkness.

J. W. P.

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CONTENTS.

Notes ... 241
Incandescent Lighting. By T. H. Seymour Hawker. (Continued.) ... 246
A Galvanometer and Battery Test. Illustrated ... 247
The Edison Central Station in Milan. Illustrated ... 248
Electric Light at Turin ... 250
Electric Jewellery and Portable Lamps. Illustrated ... 250
Accidents from Lightning ... 252
Correspondence. Illus...253 and 254
The Health Exhibition.—III. Illustrated ... 254
Experiments on the Efficiency of Incandescent Electric Lamps ... 255
Ernest Volckmar ... 258
Electro-Dynamics. By J. W. Nystrom ... 258
Dynamo-Electric Generators. (Continued.) Illustrated ... 259
The Electrical Department of St. Bartholomew's Hospital. By W. E. Steavenson, M.B. 261
Legal ... 262
Companies' Meetings—
West Coast of America Telegraph Company ... 262
Telegraph Construction and Maintenance Company ... 263
The India Rubber, Gutta Percha, and Telegraph Works Company ... 263
West Middlesex Electric Light Company ... 264
The Globe Telegraph and Trust Company ... 264
Companies' Share List ... 264
Telegraph Traffic Receipts for June, 1884 ... 264

ACCIDENTS FROM LIGHTNING.

Following on several interesting lectures delivered recently bearing more or less directly on the subject of this article there have been a series of thunderstorms, the severity of which and the fatality attending them being almost unprecedented. For some years past we have done our best to give a careful record of all such storms wherever any damage to property or life has resulted; and wherever ascertainable we have added full details of the accident with reference to the situation and character of the structure when the object damaged was a building, and the nature of the injuries sustained when the victim was a human being. But in furnishing these records we have been painfully conscious of the meagreness and inutility of our labours, the sum total leaving us pretty much in the same state of ignorance as when we begun. Looking back at our notes on this subject from week to week they remind us of a barren list of casualties at sea, without the least clue to their origin or warning as to how they might have been prevented.

This being the case, we are anxious to see some amendment in the record of casualties due to physical causes which the electrical world ought certainly to be better informed about than it actually is. A record of accidents from lightning is all very well as far as it goes, but it goes a very little way. What we require to know for scientific purposes is something quite different, and for the prevention of such accidents something far more complete. As long ago as 1855, in a Report of the Academy of Sciences, quoted by the current number of the *Edinburgh Review*, in an article on "Lightning Conductors," it was pointed out that continued and minute observation and study of the effects of thunderstorms was imperatively necessary, with a view alike to ascertain what it is that lightning spares as well as what it strikes. Nearly thirty years have elapsed since that appeal was made, and made apparently in vain. "It is," continues the Report, "of the utmost importance for the advance of man's knowledge in this branch of physical investigation that all instances of injury from lightning should be immediately examined and tested, and that all facts ascertained should be accurately described and placed upon record."

Now, what are "all" the facts which are ever vouchsafed the student in this region of inquiry? Usually they consist of the fullest details on all irrelevant points, but of no details at all on the important points. A man is "seriously injured," another one "killed;" their names, their occupations, and sometimes their ages are given with praiseworthy exactitude, but the nature of the injury, or the appearances after death, much less the actual physiological cause of death, are not deemed worthy of mention. At one place a "valuable milch cow was killed"—just as if the value of the cow added something to the severity of the shock. Eight sheep were killed at one place, and a ninth had to be afterwards destroyed. We should like to know why; more particularly should we like to know more about the three girls in Busby Mills who fell into a trance for several hours from the effects of a lightning flash. Now and again we get a useful bit of casual information, such as that of the unfortunate man at Arisaig, who was found dead with a mark like a bullet-hole on his head, and that of the cow while grazing in a field being stricken dead with no visible marks of violence, save a slight singeing of the hide; but as a rule their value is of a kind which may be gauged by the following:—The lightning came in at the front door, went up the chimney, and after visiting the bed rooms, dashed out of the attic window, doing considerable damage!

The simple fact is, that the sources of our information are not such as are likely to help us. The newspaper paragraph writer is naturally more concerned with the picturesque and the sensational than with the scientific. When the storm is over the local incident has no further interest for the outside world, and we hear nothing of the coroner's inquest which follows, or the *post mortem* examination, which it would be highly desirable should follow, though we fancy it seldom does. Perhaps an appeal to the press on this subject may be of some use, and such lectures as that of Professor Tait, which we published not long ago, and Dr. Stone's address, more recently at the Health Exhibition, may be of service in directing attention to the really useful items of information that might be added to almost all reports of accidents due to lightning. But the difficulty of obtaining what is wanted at present was well illustrated in the case of Dr. Stone, who, though the cases are all recent, and he had made special application for information respecting them, could tell his audience very little indeed

about the accidents which had occurred in connection with electric lighting.

It seems to us, however, that if any facts useful for science are ever to be got together they must be collected under scientific supervision. Some society ought to be formed for the purpose; or what would be preferable, because more immediately practicable, some existing society should take up this matter in earnest, following the clue furnished in the newspapers whenever an accident to human life occurs through lightning, and obtaining, either by personal investigation on the spot or by correspondence, precisely those particulars in which we are at present so deficient. Some extensive and valuable data have been gathered by individual observers; but it is obvious that such a work should not be left to the chance efforts of personal enthusiasm. That it has been so long neglected would seem to indicate that scientists are not altogether free from the common superstition that accidents from lightning in the open country are wholly unpreventable, the only note of warning uttered by the scientific world and heard of the people being that during a thunderstorm it is dangerous to take refuge under a tree. Whether the danger is in the situation itself or in the possibly falling tree authorities are still not wholly agreed. But lightning plays much havoc in the open, it would seem from the reports; and before we can formulate some means of protection for our flocks and herds, to say nothing of the human beings who are tending them, or are overtaken by storm before shelter can be reached—shelter itself affording doubtful safety—we must have more exact information as to the locality, the configuration of the country, its general characteristics, and any peculiarities of the particular spot that may account for the pent up forces of electricity selecting it for their discharge. We shall obviously never get what we require from the ordinary channels of information.

CORRESPONDENCE.

CALCULATING THE RELATION OF DYNAMO RESISTANCES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the report of the British Association, 1881, p. 528, Sir William Thomson gives the following equations for a series dynamo:—

$$\frac{\text{Waste}}{\text{Total work}} = \frac{R_M + R_A}{R_M + R_A + R_X},$$

and

$$\frac{\text{Useful work}}{\text{Total work}} = \frac{R_X}{R_m + R_A + R_X}.$$

In what units do you represent the terms on the left-hand sides of the equations? Do they only represent percentage as $\frac{93}{100}$ for the second equation?—Yours, &c.,

Bristol. A. T. B.

HAWKER'S SINE PHOTOMETER.

TO THE EDITOR OF THE ELECTRICIAN.

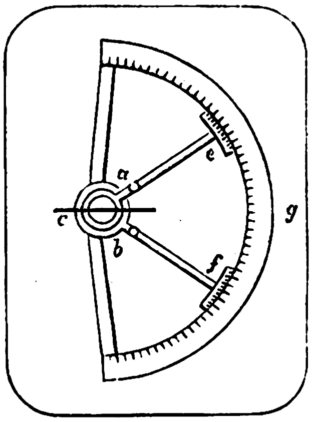
SIR: In the ordinary shadow photometers, depending for their action on the relative distances at which two luminous sources give equal intensities, there are many points which in practice render their manipulation difficult, especially to an unpractised operator, and especially when a slight difference of colour exists. A skill of eye and judgment are necessary to ensure correctness which are not at all common.

In proof of this, we have the sometimes ludicrous difference of results obtained by independent observers in identical cases; and this is naturally very noticeable in the comparison of the richly chromatic electric light with ordinary standards.

Doubtless in the future these measurements will be much simplified by the use of standard power electric lamps in such comparisons; but in the meanwhile we can but do our best to minimise the sources of error, and the writer has been led, therefore, to design a simple and yet effective instrument suitable for every day work, in which he has endeavoured to attain the desiderata of portability, rapid adjustment to any possible fluctuations in the lamp under measurement, and the direct reading off of luminous intensity in candle-power without calculation.

As shown in the accompanying plan, the instrument consists of a rectangular baseboard about 6ft. by 4in., at the centre of which is a brass sconce or short tube screwed into a circular brass plate at its lower end.

On this, as a centre, move two radial arms, each carrying a vernier seal at its extremity, and a pointed gnomon, *a b*, at a radius of about an inch from the centre. Inside the tube fits the pivot of a semicircular frame carrying a graduated arc, *g*, and supporting just above the common axis a small screen of thin translucent paper, spotted with paraffin wax. The plane of the screen coincides with a zero mark on the graduated arc, and on either side of this the graduations represent a scale of natural sines. It will be seen that the screen and graduated circle move together, while the two vernier arms which move along the edge of the graduated arc are mutually independent. The latter can, moreover, be fixed in any position by clamping screws without interfering with the freedom of movement of the screen and graduated arc.



Hawker's Sine Photometer.

c represents Screen; *a b*, Gnomons; *e f*, Vernier Indices; *g*, Graduated Arc.

To use the instrument, the two luminous sources are placed at equal distances from the centre of the screen, and separated by such an angle relative to the instrument that their lights fall on opposite sides of the screen.

Both the lamp to be measured and the standard can now be fixed, for all further adjustment is in the instrument itself.

The radial arms are now moved until the shadows of their respective gnomons fall coincidently on the central portion of the screen, and are then clamped in this position.

It will be obvious that illumination will be greatest on that side of the screen facing the most intense light in practice, and the spots of grease will then show *bright* on the opposite side.

If, however, the lights be equal, the illumination will be greatest on that side which is most directly facing the light, and least on the side most oblique to the radiations.

In other words, the brightness of the sides will be proportional to their respective areas projected normal to the light rays.

Hence, turn the screen and its attached arc on the axis until a point is attained at which the grease spots disappear, and then read off the respective angles made with the screen and vernier arms. The intensities of the luminous sources will then be inversely as the cosines of the angles.

In order to avoid the trouble of consulting tables of natural sines it is best to use sine graduation on the arcs, and in order to further simplify rapid measurements it is advisable

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to arrange so that the standard shall be normal to the screen. A single reference is then sufficient to give the relative power of the test lamp at once, without any calculation.

The compact form of the instrument enables it to be very easily boxed in free from extraneous light.

It is of course essential that the luminous sources shall be on the same plane as the instrument, but this need not be necessarily horizontal.

A very excellent screen may be made by pasting together two thin opaque gelatine films, previously shaded in lines on the inner sides.—Yours, &c., T. H. SEYMOUR HAWKER.

LAMPS WITH DYNAMOS v. BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice in your impression of 12th July two allusions to the working of some lamps which we put up on the occasion of the *conversazione* at the King's College.

While not fearing that your readers will consider Mr. O. C. D. Ross has proved the superior steadiness of primary batteries over dynamo machines by the comparison he makes between the lamps as supplied by his batteries and those exhibited by the Edison and Swan Company, I think it only fair to us and to the believers in dynamos generally to say that we had such short notice given us that our men were only able to begin work on the day the *conversazione* opened. This, however, would not alone have prevented our keeping up the credit which electrical engineers so justly claim of doing work with almost any required rapidity had it not been that at the last moment, when a start had to be made, the gas engine belonging to the college, though nominally easily able to do the work, was found to be in such bad condition as to be almost useless; indeed, had I not been obliged to be an absentee on the occasion of the *conversazione* I have very little doubt that Mr. Ross would have had no chance of making his unfavourable comparison, nor would you in your article referring to the occasion have had an opportunity of making the remarks you did. I may add that the lamps used were Swan and not Edison. Apologising for intruding on your valuable space on such a question of detail.—Yours, &c., J. F. ALBRIGHT, Resident Engineer.

The Edison and Swan United Electric Light Co.,
57, Holborn-viaduct, E.C., July 18, 1884.

THE HEALTH EXHIBITION.—III.

It is necessary that the electrician should know all about the external resistances, because he uses wire and other forms of metal in his dynamo, and the total resistances of the materials of which he makes his machine must bear a certain ratio to the total external resistance in order to give the best results. So far we have only looked at the terminals of the dynamo; we will look a little more closely into the parts of the machine and try to find out how it acts. Perhaps the better way will be to build up an elementary machine. The toy shops have made us familiar with a magnet, but because we are familiar with a toy magnet it does not follow that we understand the magnet as used in dynamo machines. If we take a bar of soft iron, AB (Fig. 1), and wind around it a piece of insulated wire, CD, we obtain part of the requisites of what is termed an electro-magnet. If we pass the blade of a knife backwards and forwards close in front of the ends A or B of the bar AB, the knife passes just as it would through air at any other point; but now, if we join the ends of the wire CD to the terminals of an electric battery so as to get a current of electricity through the wire, we find certain changes take place, not only in the wire but in the iron around which the wire is wound. Passing the knife again backwards and forwards in front of A or B we find that it is not so easy to move the knife, in fact it seems as if we have really to cut through something. The iron seems to have thrown out in every direction a number of invisible tendrils, which have to be cut before the knife gets through. These invisible tendrils have been termed "lines of force," and the whole apparatus an electro-magnet. The ends of the iron core are termed the "poles" of the magnet. Generally the iron core is bent into a U shape, so that the poles are much nearer each other than in the straight form. We shall assume that the reader has some knowledge of magnets, knowing for example that the two poles are known as the north pole and the south pole respectively, and also that the north pole of one magnet seems to repel another north pole and attract a south pole.

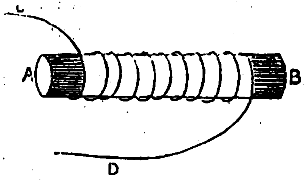

FIG. 1.

It has been found that if a wire—a copper wire, for example—is passed backwards and forwards in close proximity to the poles of a magnet, a current of electricity is generated in the wire so moved. In order easily to obtain indications of such a current, the wire must form part of a complete conductive circuit. Now suppose one part of this circuit to consist of a carbon filament, the current passing to and fro through the filament as the wire was moved backwards and forwards in front of the pole would make the carbon hotter than the copper wire, and, indeed, if the current were sufficiently powerful, would render it incandescent. This fact is made use of in the dynamo, which, indeed, is a machine for passing a wire or wires backwards and forwards in front of the magnet poles. A rough diagram will show this. AB represents the horseshoe magnet with pole pieces fashioned as at CD (Fig. 2). These pole pieces are called the field magnets, and that portion of space which contains the lines of force of the field magnets is called the "magnetic field." We ought to have stated that the lines of force starting from one pole find their end at the other pole, so that each line of force may be looked upon as a closed curve, the curve going partly through the iron and partly through the air. Any conductor interfering with these curves, that is, breaking through them or cutting them, undergoes change and is said to be electrified. If, as we have said, a closed wire is the interfering substance, we get indicated in it a current, and this current is proportional to the number of lines cut by the wire.

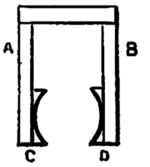

FIG. 2.
Field Magnets of Dynamos.

The lines of force commence say at C and end at D, going across the air space pretty well straight. If we take a cylinder (Fig. 3) and wind wires around it, W W W, fixing the axis of the cylinder so that the wires can be rotated in front of C and D, we get a current in the wire when the electro-magnet is excited by a current and the cylinder rotated. This rotating part is called the "armature." The wire of the armature and the wire and lamps external to the machine in reality form one continuous circuit. It would not be very economical, however, to have a machine made in this elementary manner. Dynamos may be classified according to the winding of the field magnets or the construction of the armature. All machines give a current first in one direction, then in the opposite or alternate current. With some machines the alternate currents are used, and these are called alternate current machines; while to others is added an arrangement whereby the alternate currents are so directed that the currents used are in one direction only. These latter are called direct current machines.

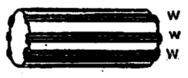

FIG. 3.
Elementary Armature.

Let us consider the various ways which have been suggested as regards the winding of the field magnets.

1st. THE SERIES METHOD.—We have explained that the current is generated in the rotating armature coils. From the coils it may be said to go to one of the collectors or brushes, from the brushes to the + terminal, and from this terminal through the external circuit to the other terminal, then to the other brush, and so completing the round. This explanation may not be altogether scientific, but for the moment it will help us in getting a fair idea of what goes on. In the series

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method of winding, the main wire goes from the + terminal round first one and then the other arm of the electro-magnet, thence to the lamp circuit, and so to the other terminal. Fig. 4 shows this. T and T' represent respectively the + and − terminals; M M the arms of the electro-magnet.

2nd. THE SIMPLE SHUNT METHOD.—The current round the arms of the field magnets is taken not from the main but by means of a branch wire. The total current generated

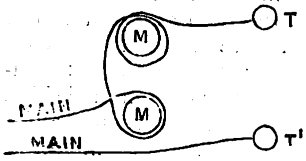

FIG. 4.
Series Method of Winding.

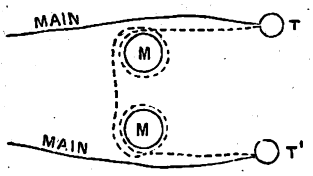

FIG. 5.
Simple Shunt Method.

divides itself between the main and branch wires inversely as the resistances of these wires. Thus, if the resistances be represented by x and $2x$, the current will be represented by 2 and 1 respectively. Fig. 5 shows this system. As before T and T' represent the terminals. The main wire is shown by a thick line, the shunt wire by a dotted line round the magnet arms M M.

3rd. THE COMPOUND METHOD.—In this system, as shown by Fig. 6, the magnet arms are wound with both a shunt and the main wire.

4th. THE COMPOUND SHUNT.—We do not know that any of the machines in the market are constructed upon this plan, but it will easily be seen that the number of branches or shunts is not limited to one. It has been suggested, then, that

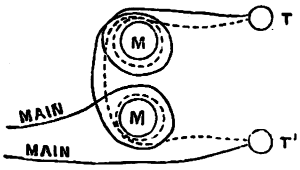

FIG. 6.
Compound Method.

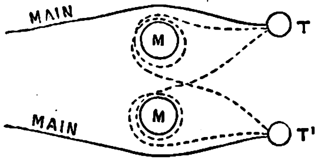

FIG. 7.
Compound Shunt Method.

there shall be a branch or shunt for each arm of the magnet. Two shunts thus used can be used either to make one ordinary machine, two ordinary machines, two unipolar machines, or a more perfect machine of a type similar to the Jurgensen. So far as we know this is the only direct way of getting a unipolar machine. The method is shown by Fig. 7, where T T' represent the terminals, the dotted lines represent the two shunt wires, the thick line the main wires. Making the resistances of the shunts equal the effect of each wire will be the same, and according to the direction of winding the poles can assist or oppose each other. If the resistances are unequal, either assistance or opposition can be obtained by the manner of winding, and by this means a good deal of governing can be done.

The above are the various ways of winding the field magnets. The current through the field magnet wires is not always obtained from the armature of the machine, but ofttimes a separate small machine is used to generate the current for these wires. The machine so used is termed the "exciter," the machine so excited is called the "generator."

LIGHTNING AND TELEGRAPH MATERIAL.—An interesting return has been made of the injuries sustained by telegraphic apparatus in France during 1883. The following ratios of damages are per 1,000 of the various articles in use:—

Poles	·742	Bells	6·40
Insulators	·168	Morse Apparatus ...	2·777
Lightning Protectors	17·37	Printing Apparatus (Hughes & Bandot)	0
Galvanometers	·44		

EXPERIMENTS ON THE EFFICIENCY OF INCANDESCENT ELECTRIC LAMPS.*

BY HORACE B. GALE.

These experiments were made by the writer in April and May, 1883, when a student in mechanical engineering at the Massachusetts Institute of Technology, and furnished the material for a thesis, from which what follows is selected for publication.

The object of the tests was to ascertain the efficiency of each of the principal forms of incandescent lamps when run at various candle-powers. The efficiency, as the term is here employed, is measured by the number of candle lights produced per horse-power of electrical energy expended in the lamps themselves.

As much of the work as possible, including the calibration of the instruments used, was done in the laboratories of the institute. The other experiments were made at one of the lighting stations of the New England Western Electric Light Company in Boston, as the necessary dynamo power could be more readily obtained there than elsewhere. It should be stated, however, that this company had no part in the experiments, and no knowledge of the results, except what was gained afterwards by inspection of the diagrams presented herewith. The forms of lamp tested were the Maxim, the Edison, and the Bernstein. Measurements of the Swan lamp, which it was intended also to include, had to be omitted on account of the limited time which could be spared for the work.

Before describing the experiments, a few words may be devoted to the

General Principles

which govern the efficiency of an incandescent lamp. Each of the lamps mentioned consists essentially of a filament of carbon enclosed in a glass globe, from which the air has been exhausted, the ends of the filament being joined to two platinum wires, which pass through, and are sealed into the glass. These wires form the connections by means of which a current of electricity is sent through the carbon. The energy which must be expended to force the electricity through the resisting substance of the filament is transformed into heat, which shows itself by raising the carbon to incandescence.

The heat escapes from the carbon filament in three ways: first, a little is conducted away by the connecting wires; second, a still smaller amount, probably, is transferred to the glass by the rarefied gas left in the globe; third, the remainder, which represents practically the whole energy expended in the lamp, escapes from the carbon by radiation. This radiation consists partly of invisible heat, and partly of light; and it is clear that the most efficient lamp is the one in which the largest part of the radiant energy is in the desirable form of light. In other words, the efficiency of an incandescent lamp depends solely upon the proportion between the quantity of energy which is given off as light and that which is wasted as invisible heat.

Now the ratio between the quantity of light radiated and the quantity of heat radiated by any solid body depends upon its temperature. The shape or structure of a body, or the extent of its surface, though influencing the total amount of radiation, cannot affect the proportion of the light and the heat.

By adjusting the strength of the current passing through the carbon of an incandescent lamp, we may heat it as hot as we please. We may raise it to a moderately high temperature without getting any light at all, all the energy expended being wasted in the form of heat; increase the quantity of electricity passing through the filament, and we can bring it to a dull red; again augment the current, and it glows with a feeble yellow light; and now, if the current is made a little stronger, without adding much to the amount of *heat* radiated, the intensity of the *light* becomes enormously increased. The way in which the candle-power rises, as the current strength is augmented, may be seen in the following table, based on a

* Reprinted from *Van Nostrand's Engineering Magazine.*

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series of measurements made upon a Maxim "B lamp," designed to give about nine candle-power.

The efficiency of a lamp—that is, the return we get in light for a given amount of electrical energy, being greater the higher the degree of incandescence to which the carbon is brought, it follows that by varying the candle-power of any incandescent lamp, we may, within certain limits, make its

Current strength in amperes.	Candle power.	Increments of current strength.	Increments of candle-power.
0·	0·		
0·5	0·	0·5	0·
1·0	(very dull red).	0·5	0·
1·5	3·5	0·5	3·5
2·0	17·0	0·5	13·5
2·5	55·0	0·5	38·0
3·0	120·0	0·5	65·0

efficiency as high, or as low, as we choose. On the other hand, the hotter the carbon is heated the sooner it is disintegrated and destroyed. A gradual transfer of particles of carbon takes place from the filament to the inner surface of the glass globe; the latter becomes darkened, the resistance of the carbon is raised, and finally the filament breaks at its weakest point.

It is worth noting in this connection, that in the experiment referred to above, the Maxim lamp was run for about 15 minutes at more than 10 times its normal candle-power without apparent injury, a fact which speaks well for the endurance of this form of lamp.

While the *efficiency* of an incandescent lamp is thus a matter of temperature chiefly, being greater the higher the temperature, its *durability* depends both upon the temperature and upon the form, structure, and density of the carbon, as well as upon the perfection of the vacuum obtained in the globe. The *relative economical importance* of the efficiency and the durability of a lamp will vary, of course, in different circumstances, according as the cost of the power or the cost of renewing the lamp is the greater; and if we can discover the law connecting the efficiency, length of life, and candle-power of a given form of lamp, we can determine, for each special case, at what candle-power the lamps should be run in order to obtain the greatest economy.

Description of Lamps.

The peculiarites of the various types of incandescent lamps depend mainly upon differences in the carbon filament.

The carbon of the Maxim lamp is made from paper, cut with a die to a shape somewhat like a letter M with its angles rounded. After carbonisation, the filament is placed in a rarefied atmosphere of hydro-carbon vapour, and heated by the current. The vapour is decomposed, and its carbon is precipitated upon the filament in such a way as to obliterate all inequalities in it.

Three styles of Maxim lamp were used in these experiments, rated respectively at 12, 24, and 16 candle-power. They were obtained at the Stanhope-street electric light station in Boston, and were taken at random by the writer from a large stock on hand at that place.

The carbon of the Edison lamp is a long, fine filament, made from Japanese bamboo wood, cut to the requisite size in a gauge, and bent into the shape of a U. Three varieties of Edison lamps were experimented upon, rated as 8, 10, and 16 candle-power. These lamps were sent from the factory of the Edison Company at Newark.

The Bernstein lamps used in these tests were peculiar in many respects, perhaps the most striking peculiarity being their very low resistance. The carbon consisted of a straight hollow tube, about an inch and a quarter long, of the size of a straw, and terminated by two knobs or bulbs of carbon about a quarter of an inch in diameter, into which the ends of the connecting wires entered. These lamps were obtained by the writer from the factory in Boston. They were rated at 30 candle-power. As they had scarcely passed their experimental stage, and have since been improved, the results obtained from them are not presented here as fully as are those obtained from the Edison and Maxim lamps.

Resistance Cold.

The following table shows the resistance of the various lamps when cold. The numbers here given were marked on the bases of the individual lamps to identify them. The resistances were measured with a large new Wheatstone bridge, made by Williams, of Boston, which was used as a standard of resistances throughout the work. Before using it the coils were tested by comparison with those in the Physical Laboratory at Harvard College. The galvanometer used in the bridge was a Thomson double coil reflecting instrument of 5,000 ohms resistance, made by Elliott Brothers, London. It was mounted on a pier of masonry, and furnished with a compensating magnet and shunt coils, so that it could be made as sensitive as desired.

Resistance of Edison Lamps, Cold.

(Temperature of room, 68°.)

10 candle lamps.	8 candle lamps.	16 candle lamps.
Ohms.	Ohms.	Ohms.
No. 21, 380·0	No. 16, 125·0	No. 11, 300·0
„ 22, 377·5	„ 17, 111·0	„ 12, 300·0
„ 23, —	„ 18, 114·0	„ 13, 291·0
„ 24, 384·0	„ 19, 107·0	„ 14, 268·0
„ 25, 396·8	„ 20, 108·5	„ 15, 297·5
Average, 384·58	Average, 113·10	Average, 291·30

Resistance of Maxim Lamps, Cold.

24 candle (A) lamps.	B-lamps ("half-lamps").	16 candle lamps.
Ohms.	Ohms.	Ohms.
No. 1, 75·0	No. 30, 34·0	No. 41, 148·3
„ 2, 74·6	„ 31, 32·2	„ 42, 149·2
„ 3, 74·4	„ 32, 34·7	„ 43, 148·3
„ 4, 76·0	„ 33, 35·0	„ 44, 150·0
„ 5, 75·4	„ 34, 34·3	„ 45, 153·4
Average, 75·08	Average, 34·04	Average, 149·84

Resistance of Bernstein Lamps, Cold.

30 candle lamps.

No. 1	4·37 ohms.
„ 2	6·47 „
„ 3	1·83 „
„ 4	1·42 „
„ 5	—
Average	3·52 „

The Photometer.

The measurements of candle-power were made upon a photometer of the ordinary Bunsen type, having a bar 100 inches long. The disc was enclosed in a box about a foot long, having an opening in each end to admit light, and two mirrors so arranged that both sides of the disc could be viewed at once from an opening in front. The box carrying the disc could be rolled on wheels along a horizontal track, and a

pointer projecting downward opposite the disc indicated on a graduated scale the ratio of the intensities of the two lights at the two ends of the bar. The whole was placed in a dark room, the interior of the room, and also the apparatus itself, being painted a dull black.

Illumination at Different Angles.

On account of the shape of the carbon filament, incandescent lamps generally give more light in certain directions than in others; and it is important to know exactly what the variation is, so that we may calculate, from a single measurement of the intensity of the light in a given direction, what is the true average candle-power of the lamp. This point was accordingly investigated for each one of the lamps. The method used was to place two lamps of the same kind, connected either in series or in multiple arc, at opposite ends of the photometer bar, and send a current from the same source through both. One of the lamps was then turned about its vertical axis through ten degrees, or less, at a time, as indicated on a graduated circle, and the intensity of the light given off at each angle was compared with that of the other lamp, which remained fixed, and served as a standard.

The principal advantage of this method is, that if any accidental variation in the current should cause the candle-power of the lamp tested to vary slightly from its normal value, the brightness of the standard lamp will vary in the same way, so that the ratio of the candle-powers will not be affected. It was found that in this way these experiments could be carried on equally well with a current of variable intensity as with a steady current. In all the tests here described, however, the current was kept perfectly steady, by a method which will be described further on.

The values of the illumination of each lamp at the different angles were laid off graphically from a centre, and a curve drawn through the points thus found. The area of each curve was then measured with a planimeter, and the ratio of the true candle-power to the candle-power as measured on the face of the carbon loop (*i.e.*, perpendicularly to its plane) was computed for each lamp. The average results for each class of lamps were also plotted in the same way.

The photometric measurements were made only in a horizontal plane, because that is the usual method of measuring candle-power, though perhaps a fairer comparison of the different lamps would be arrived at by taking the average spherical illumination.

Referring to diagram No. 1, the outer curve represents the illumination of the old style, or 24 candle-power, Maxim lamp; and the inner curve that of the Maxim lamp as improved by Mr. Weston, which is the style at present made by the United States Electric Lighting Company, and rated at 16 average candle-power. The curves are drawn so that if one imagines the lamp placed in the centre, the plane of the carbon filament being represented by the line 0-0, all points on the curve will be equally illuminated. The carbon of the Maxim lamp being made from paper is several times as broad as it is thick; hence we see that the illumination opposite the face, or flat, of the carbon is considerably greater than that on the edge. The variation in brilliancy, as we go from the edge (marked 0) round to the face, is extremely regular for the Maxim lamps, the curves of the individual lamps being almost identical.

Diagram No. 6 shows the same thing for the Edison lamps. Here the carbon filament has its greatest breadth in the direction perpendicular to the plane of the loop, so that the illumination is feeblest on the face, and increases as we go towards the edge. Just in the plane of the loop, however, there is a sudden falling off in the intensity of the light, because when the two arms of the U are exactly in line one cuts off the light of the other. Though these curves, each showing the average of five lamps, are tolerably regular, the curves for the individual Edison lamps are quite irregular, owing to the carbon being more or less twisted.

The illumination of the Swan lamp, one of which was tested at this time, was found to be the most uniform, being practically the same in all directions. It is claimed, however, that a uniform illumination is not always an advantage, as it is often desirable to be able to throw more light in certain directions than in others.

In each of the diagrams a circle is drawn, whose area is equal to the area of the irregular figure bounded by the curve of equal illumination, and the intersection of the circle with that curve gives us the angle at which we should measure the light of the lamp in order to get its true average candle-power. A better way, however, and that here adopted, is to measure the candle-power of each lamp on the face, and compute its average candle-power by referring to the curve for that individual lamp.

Source of Current.

For experimenting upon incandescent lamps, it is desirable to be able to maintain, for any length of time, a perfectly uniform and steady current of electricity. The available sources of current were in this case a Weston fifteen arc light dynamo machine, having the field in derived circuit, and a Kabath secondary battery of seventy-two cells. The current of the dynamo machine, though tolerably steady, was not perfectly so, on account of slight variations in the speed; and that from the storage batteries, though not subject to fluctuations, would nevertheless run down gradually as the cells became discharged. By using the machine and the battery in combination, however, it was found possible to maintain a current of a perfectly uniform intensity for any desired time. The batteries were connected in series, so that any number of them might be placed in the circuit of the dynamo machine, in derivation with the loop supplying the lamps. The current passing through the lamps could be regulated by means of an adjustable resistance, or by varying the number of cells of the battery in circuit; and a variable resistance was also interposed in the field circuit of the dynamo, so that its electromotive force could be adjusted to just balance that of the battery. The dynamo thus supplied the current to the lamps without exhausting the battery, which merely served to keep the electromotive force on the lamps constant, and absorb any fluctuations that might exist in the current of the dynamo. When the lamps were turned off, the dynamo merely supplied the loss due to leakage and local action in the cells. This arrangement of balanced electromotive forces is, of course, not possible with a dynamo having the field coils in direct circuit.

The Measurements of Current

were made by means of one of Ayrton and Perry's ammeters, which was carefully calibrated at intervals during the progress of the tests by comparison with a tangent galvanometer. The constant of this galvanometer was computed from the number and diameter of the coils, and the value of the horizontal component of the earth's magnetism as determined at Cambridge, and was also ascertained directly by the electrolysis of a solution of pure sulphate of copper. The results of the two methods were found to differ by less than one per cent.

Determination of Galvanometer Constant.

In the determination by the deposition of copper, three large Daniell cells, whose joint resistance in parallel circuit was about ·08 of an ohm, were used as a source of current; the circuit was completed through the galvanometer, a resistance box, and a depositing cell with a copper anode and a platinum cathode, the liquid being a saturated solution of chemically pure sulphate of copper. The resistance was first adjusted to obtain a deflection of the galvanometer needle of a little more than 30°. The platinum cathode was then removed from the cell, washed with distilled water and alcohol, dried, and weighed. The circuit was again closed by lowering the cathode into the solution, and the deflection of the galvanometer was kept constant for about an hour and a half, when the circuit was broken by taking out the cathode, which was washed, dried, and weighed, as before. The data for calculating the galvanometer constant were as follow :—

Increase in weight of the cathode.........	0·22208 gram.
Time during which the current passed ...	5095· seconds
Deflection of galvanometer	34·675 degrees.
Tangent of deflection	0·6918.

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Assuming that one ampere of current deposits ·00033 gram of copper per second, as given by Prof. S. P. Thompson in his "Electricity and Magnetism," we have—

$$C = \frac{0{\cdot}22208}{5095 \cdot \times {\cdot}00033} = 0{\cdot}132 \text{ ampere.}$$

Hence the galvanometer constant

$$= \frac{0{\cdot}132}{{\cdot}6918} = 0{\cdot}19.$$

The galvanometer had 36 coils, whose mean diameter was 52 centimetres. Computing from these data the value of the horizontal component of the earth's magnetism, we obtain H = 0·165. The value of H, as determined at Cambridge in 1882, was 0·164.

Calibration of Ammeter.

To calibrate the ammeter it was put in circuit with the Daniell battery, a resistance box, and galvanometer, the current being divided between the latter and a shunt of No, 12 copper wire. The multiplying power of this shunt was 13·29. By adjusting the resistance the reading of the ammeter was varied by one degree at a time from 0° to 22°, deflections being taken both to the right and left, and simultaneous readings made of the galvanometer. The deflection of the ammeter was found to be proportional to the current, as far as the test could be carried, after making correction for a permanent displacement of the zero point of 0·14°, which was allowed for in all the subsequent work. The ammeter was again calibrated near the middle, and again at the close of the experiments, the results agreeing with the first calibration; thus showing that the strength of the permanent magnet had not altered perceptibly while the work was in progress.

Second Series of Tests.

The object of the next series of observations was to obtain the data from which curves could be constructed for each lamp, showing the variation in candle-power and current strength as the electromotive force is increased. The method consisted in varying the candle-power of each lamp by a succession of steps, from zero to as high a point as it could safely be carried, and taking simultaneous measurements of the electromotive force, current, and candle-power at every point.

Determination of Electromotive Force.

The current passing through the lamp could be ascertained directly by means of the ammeter; but the resistance of the lamp when hot being unknown, to find the electromotive force it was necessary to place the lamp in derivation with a coil of wire of known resistance, and measure at the same time the current passing through this coil. The electromotive force was then found by multiplying together the values of the current and resistance.

ERNEST VOLCKMAR.

It is always a matter of regret to lose from among the votaries of science one whose name has become familiar, either from being engaged in experimental work or as a man of business performing duties most distasteful to the pure experimentalist. It is a matter of deeper regret when the loss is not altogether in the ordinary course of nature. Mr. Ernest Volckmar (whose body was recently found in the Seine) first became known in the electrical world in his connection with secondary batteries. He was born at Kiel, in Germany, on 31st July, 1847. In 1866 he went to Paris, and two years after to South America, where in 1871 he became managing partner to Messrs. Dorado and Volckmar. It was in the works of this firm that he first occupied himself with the study of electricity. He returned to Europe in 1876, and during the early stages of secondary-battery work was associated with the Faure Company, in Paris. He afterwards became a director of the Storage Company in England, that company working, among others, his patents.

ELECTRO-DYNAMICS*.

BY JOHN W. NYSTROM.

The object of this paper is to criticise the electro-dynamics advanced by Count Du Moncel in his work on "Electricity as a Motive Power," page 297, English edition, and to show the confusion in which that subject is yet involved.

The Count Du Moncel gives three formulas on page 299 intended to express the quantity of work accomplished by an electric current, namely as follows:—

$$W = RC^2 \quad \ldots \quad (1)$$

$$W = \frac{E^2}{R} \quad \ldots \quad (2)$$

$$W = EC \quad \ldots \quad (3)$$

W = work expressed in kilogrammetres.
R = resistance in the conductor expressed in ohms.
C = intensity of current expressed in amperes.
E = electromotive force expressed in volts.

No formulas can express quantity of work without representing the three simple elements—*force*, *velocity*, and *time*, and as the time is wanting in Count Du Moncel's formulas, they cannot express work.

In the simplest formula for work, namely W = FS, or the product of force and space, the time is included in the space S, which is the product of velocity and time. No work can be accomplished without time.

Work is transformed into power by eliminating the time, and the power is thus expressed "work per unit of time." And therefore no work can be transformed into power without dividing it with the time in which it is accomplished; but the Count divides work by the acceleratrix of gravity, and calls the quotient *power*, namely, as follows:—

$$P = \frac{R\,C^2}{g} \quad \ldots \quad (4)$$

$$P = \frac{E^2}{gR} \quad \ldots \quad (5)$$

$$P = \frac{EC}{g} \quad \ldots \quad (6)$$

P = power in effects, which is expressed in kilogrammetres per second.

To divide work with the constant acceleratrix of gravity, $g = 9{\cdot}81$ metres per second, which is velocity, will give a quotient of momentum of time FT, when a force F acts for a time T upon a mass free to move. Therefore the formulas 4, 5, and 6 cannot express power, or the work done per unit of time, when formulas 1, 2, and 3 mean work. It appears that the first three formulas mean *power*, which multiplied by time T seconds will give work.

The term *intensity* of current is evidently intended to mean a definite physical quantity, which should have a definite unit of measure; but *intensity* is applied to heat, light, and other phenomena without a definite meaning.

It is evident from the formulas, and also by the mode of measuring *intensity* of current by a galvanometer, that *intensity* means velocity of the electric current, and can, consequently, be expressed by any unit of length per unit of time. Ampere is the unit of measure of *intensity* of current, which can be expressed by a unit of velocity. The present value of one ampere is, or should be, a velocity of 1,000 kilometres per second. Therefore, the term *intensity* should be abolished in that connection, and it should be called what it really is, namely, *velocity* of current, and denoted by V instead of C, which would make the expression intelligible and definite.

Electromotive force is an expression of a definite physical quantity, which can be measured by any unit of weight, but the unit *volt* does not convey an idea of a definite unit of weight or force. The electromotive force of one *volt* is a weight or force of about one milligram. The term *volt* should therefore be

* Paper read before the Electrical Section of the Franklin Institute, June 13th, 1884.

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abolished in that connection, and it should be called what it really is, namely, *milligram*, and the electromotive force should be denoted by *f*, which means force. These proposed changes would make the subject intelligible and definite, as in mechanics, where we have the well-known physical elements *force*, *velocity*, and *time*, the combination of which gives the functions *power*, *space*, and *work*.

The old and new forms of electro-dynamics would compare as follows:—

	Old Form.		*New Form.*
Power	$P=\frac{RC^2}{g}$.	......	$P=V^2$.
	$P=\frac{E^2}{gR}$.	......	$P=\frac{F^2}{R}$.
	$P=\frac{EC}{g}$.	......	$P=FV$.
Work	$K=RC^2$.	......	$K=RV^2T$.
	$K=\frac{E^2}{R}$.	......	$K=\frac{F^2T}{R}$.
	$K=EC$.	......	$K=FVT$.
Resistance	$R=\frac{E}{C}$.	......	$R=\frac{F}{V}$.
	$R=\frac{gP}{C^2}$.	......	$R=\frac{P}{V^2}$.
	$R=\frac{E^2}{gP}$.	......	$R=\frac{F^2}{P}$.
Electromotive force.	$E=RC$.	......	$F=RV$.
	$E=\sqrt{gRP}$.	......	$F=\sqrt{PR}$.
	$E=\frac{gP}{C}$.	......	$F=\frac{P}{V}$.
Velocity of current.	$C=\frac{E}{R}$.	......	$V=\frac{F}{R}$.
	$C=\sqrt{\frac{gP}{R}}$.	......	$V=\sqrt{\frac{P}{R}}$.
	$C=\frac{gP}{E}$.	......	$V=\frac{P}{F}$.

Time of operation in seconds .... $T=\frac{W}{RV^2}$, $T=\frac{WR}{F^2}$, $T=\frac{W}{FV}$.

P = power in effects, which is expressed by kilogrammetres per second.

R = resistance of conductor in ohms.

E = F, the electromotive force expressed in milligrams.

C = V, the velocity of the electric current in thousands of kilometres per second; that is, when V = 1, the velocity is 1,000 kilometres per second.

T = time of operation in seconds.

W = work in kilogrammetres.

There are 75 French effects per horse-power.

There is a discrepancy between the old and new formulas for power, which is caused by Count Du Moncel dividing the work by the acceleratrix *g*, and calling the quotient *power*. Therefore his formulas for work do not agree with his formulas for *power*.

The new form gives the *power* ten times greater than the old form, on account of the unit of electromotive force being assumed to be one milligram, and the unit of *velocity* 1,000 kilometres per second, which ought to be the units of these quantities.

Comparison of French and English units of power and work.

English.		French.	
Effects P.	HP.	Effects P.	HP.
1	0·001818	0·1382	0·00184
550	1	76·2	1·0136
7·2334	0·00178	1	0·01333
542·47	0·9863	75	1

The numbers which express units of power are equal to the numbers which express units of work done per unit of time, but the quantities, power, and work are different from one another, as explained above.

I beg leave to repeat what I have stated many times within the last twenty years, namely, that the science of electricity can never be cleared up before the electrical savants learn to understand dynamics. The greatest difficulty they have to encounter appears to be the distinction between *force*, *power*, and *work*, which quantities they now confound with one another.

The difference between *force*, *power*, and *work* is respectively the same as that between *length*, *surface*, and *volume*.

DYNAMO-ELECTRIC GENERATORS.

(CONTINUED FROM PAGE 234.)

Classification.

Let us now consider the classification of machines. Briefly, an electric generator is composed in the main of three parts: 1st, the magnets, for producing the necessary magnetic field; 2nd, the moving armature, for the generation of the current; and 3rd, the apparatus for collecting the current. Most of the modern machines giving a continuous current have two free poles only, and generally these poles may be regarded as the union of two like poles—that is, a core of iron is wound with two sets of wire, the middle being left free, and the two coils so joined that the current passes in opposite directions at the two ends of the core, thus producing a pole in the centre, and if the ends are free two opposite and simple poles at these ends.

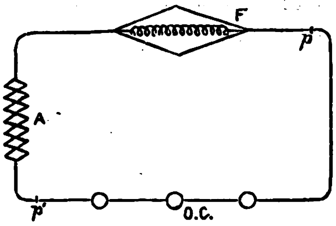

Fig. 1.—Series Arrangement.

A second core being wound so as to form a pole of opposite character, the four free ends are joined, thus forming a closed iron ring of irregular shape with two poles. These cores may be either of cast iron or soft iron—the latter, leaving out the question of cost, being of course preferable. Several machines, generally those giving an alternating current, have several field magnets. To both these rules, however, there are marked exceptions, some of which will be noticed later, for these are continuous current machines which have more than two free poles, and alternating machines with only two. The earlier machines used permanent steel magnets, and there are powerful machines, notably the De Meritens, which are still made with them. Ordinarily, however, an electro-magnet may be made more easily and quickly, and its magnetic field is more intense.

To excite the electro-magnets there are several ways.

1st (Fig. 1), by the series arrangement. In this the armature system of coils, the field-magnets, and the lamp, or external circuit, are joined in one complete circuit, so that the whole current generated flows over all parts. Starting with the residual magnetism in the iron, a very light current is

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formed; this flowing through the field coils intensifies the magnetic field, which in turn strengthens the current, and so on, the augmentation of current increasing until the magnets are saturated. This point of saturation is very quickly reached.

2nd (Fig. 2), the shunt method. This was proposed by Wheatstone, and brought into prominence by Siemens. In this the current from the armature system divides, a part flowing through the lamp circuit and a part through the field coils. If now the resistance of the external circuit is increased, instead of lessening the current in the field coils it is increased, the magnets become stronger, and the current in the lamp circuit is kept up to its proper strength, or nearly so. Siemens used a shunt of moderate resistance.

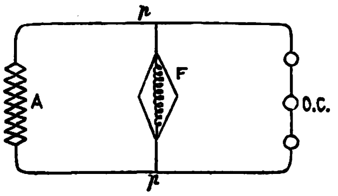

FIG. 2.—Shunt Method.

For the purposes of supplying currents which will vary inversely as the external resistance, Edison has introduced the high resistance shunt and the use of very heavy fixed magnets. By the use of large masses of iron the saturation point is less quickly reached and a more powerful machine made with a given armature, construction, and speed. It must be noticed that the characteristic curves vary a good deal with different relative normal resistance of armature, field, and external circuit, and differently dimensioned field magnets.

By the arrangement shown in Fig. 3 it is probable that very satisfactory results would be obtained. Here the field coils are in two sets, one at least being of low resistance. Through this whole armature current flows, then dividing so that part flows through the second system and the remainder through the lamp or external circuit. Another method of exciting the field magnets is by means of a second continuous current machine, this latter being a self-exciter; or a generator may have two independent systems of armature coils and two commutators, the current from one system feeding the field, and from the other the lamp circuit. In both arrangements the field is practically independent of all fluctuations of the main current due to the changes in the external resistance. I say practically independent, for the field is somewhat affected

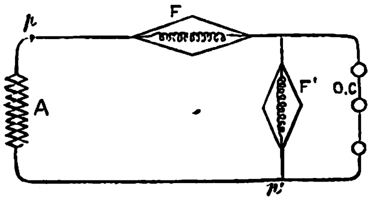

FIG. 3.

by the strength of the poles in the armature. Alternate current generators are usually excited by a second machine, although two or more systems of armature coils have been used. The armatures of electric generators may be divided into four classes—drum, ring, disc, and pole armatures.

1. *Drum.*—In this class the coils of wire are wound longitudinally—that is, along the element of a cylindrical drum. This drum may be either hollow or solid, magnetic or non-magnetic. The coils may or may not be wound in diametrically opposite divisions. They are generally so wound, and the drum rotates in close proximity to wide polar surfaces, the current generated, which is taken off by a commutator, being continuous.

2. *Ring.*—To this class belong all which have an iron ring or cylinder, which is enclosed by a series of coils. The ring may be perfectly regular, and entirely enclosed by the coils, or its surface may be broken up by projections, the coils being wound in the spaces between. There may be either one ring or several, the coils being connected in series, so that a continuous current is generated. This ring is rotated usually between two wide polar extensions, although more than two poles have been used.

3. *Disc.*—These may be described as having the active portion distributed in a thin disc or wheel, the axes of the cores being parallel to the shaft. Several field magnets generally obtain, the poles being ranged in an alternating opposition and but a short distance apart. These machines may be either continuous or alternate current generators.

4. *Pole.*—This is a very numerous class, embracing all the earlier machines, as well as a number of the modern ones. The Elias machine, although having a ring armature, depends for its action on the polar principle—that is, on the change of state, relative or absolute, of iron or steel magnet cores. Generally speaking, the machines of this class are not so efficient as those belonging to the other classes, especially when used for continuous currents. There are, however, one or two notable exceptions.

The other classes, as well as the fourth, generally use soft iron in the construction of the armature, and in some this is absolutely necessary for any efficient work. The more especially must it be used where the poles of the field magnets are far removed for the purpose of intensifying and directing the magnetic field, and where the wire is so wound that some portion must be screened from the magnetic field to prevent a counter electromotive force being generated, to the detriment of the machine's efficiency. In some of the disc armature machines, the poles being close together, iron is unnecessary between them, and the coils are so wound that the inactive parts are out of the magnetic field, or cut it in a lineal direction. In all cases where iron masses are rotated in a magnetic field they behave as any other conductor—that is, currents are generated, and these currents, circulating in the iron, rapidly heat it. Not only is a considerable amount of work thus absorbed, but the heat generated injures the wire conductors, and generally lessens the efficiency of the machine as a converter of mechanical into electrical energy. If the iron is not soft the change of magnetic state is opposed; it is not really magnetised, nor does it easily lose or reverse its magnetisation.

All these qualities are objectionable, but the use of iron being often necessary, whenever it must be rotated it should be as pure as possible, and well broken up, in which case the work is much lessened.

Of the particular action of iron screens and cores, and the means used to lessen their adverse influence, I will speak more at length in dealing with particular machines.

Machines Exhibited.

I have now to speak in detail of the principal machines exhibited, and of the theory and practice of their operation. Although some of these were exhibited by several companies, I will associate each with one only.

The generators were as follow:—

1. RING.

Gramme—British Electric Light Company.
Brush—Anglo-American Brush Electric Light Company.
Schuckert—Rowatt and Fyfe.
Maxim—Electric Light and Power Generator Company.
Bürgin—R. E. Crompton and Co.

2. DRUM.

Siemens (continuous current)—Siemens Bros.
Edison (wire armature)—T. A. Edison.
Edison (bar armature)—T. A. Edison.
Weston—Electric Light and Power Generator Company.

3. DISC.

Arago Disc (continuous current)—White House Mills.
Arago Disc (alternate current)—White House Mills.
Siemens (alternate current)—Siemens Bros.

4. POLE.

Lontin—Electric Light and Power Generator Company.
Lachaussée—Gerard and Co.

5. POLE AND RING.

Gramme Auto-Exciting—Compagnie Générale.

(TO BE CONTINUED.)

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THE ELECTRICAL DEPARTMENT OF ST. BARTHOLOMEW'S HOSPITAL.*

BY W. E. STEAVENSON, M.B.

The importance which electricity has acquired in its application to medicine induced the Governors of the Hospital, at the suggestion of the medical staff, to appoint a qualified medical man to organise and undertake the management of a complete electrical department. This appointment was made in October, 1882, and I was so far honoured as to be selected for the post. The formation of such a department involved a considerable outlay, and therefore careful consideration and inquiry, so that the money expended might be used to the best advantage. A sub-committee of the staff was appointed to consider the matter, and to advise and assist me in its arrangement. The plan has developed so far at the present time as to justify me in giving an account of what has been accomplished, and also an outline of the electrical work which has been done in the hospital during the past year.

The exigencies of electricity demanded that the place selected for it should be warm and dry, that there should be space for the electrical machines and apparatus, and that these should not be subject to continual movement and disturbance, as would be the case if the room was used for any other purpose, and that there should be accommodation for the patients while waiting for treatment and for dressing and undressing, so that the whole business of the department should not be unnecessarily retarded.

It was ultimately decided to convert the room until recently used as the Coroner's Court into several compartments in which the different forms of electricity as used in medicine might be applied. One feature is the estabishment of a workshop in which all the minor repairs of the electrical apparatus used in the hospital will be carried out. It is hoped that great saving both in time and money will result from this arrangement. The man employed to make these repairs will also have the custody of the building in the absence of the medical officer. He will receive notices from the wards of patients requiring electrical treatment by the electrician, and supply and receive back again the batteries used in the wards by other medical officers. He will also prepare the galvano-cautery batteries when they are required, and take them to that part of the hospital in which they may be wanted. In the room I have marked as No. 1 there will be a frictional machine for producing statical electricity, and an insulated couch and benches; also a small table for operating. The electricity for this purpose will be conducted from the cellar below, in which will be placed a powerful Bunsen's galvano-cautery battery of six cells. The necessary operating instruments will be kept in this room. There will also be an element board connected with sixty modified Leclanché elements (also in the cellar) for producing a continuous current for galvanic purposes. An additional tray of six cells will be used to work an induction coil for producing an interrupted current. A couch will be placed under this element board on which the patient can recline, and it will be possible to use the galvanic or faradic current at will. In room No. 2 will be a similar element board connected with the same number of cells and worked in a similar manner, but it will also be possible to use the current for the electric bath in the adjoining compartment. The portable batteries for use in the department and for lending to the wards will also be kept in this room, and also the electro-magnets belonging to the hospital. In the centre of the building a lobby has been formed, provided with benches for the patients while waiting for treatment.

I can best show the amount of electrical work done by myself in the hospital during the year by a tabular arrangement. I have given in each case the reason why electricity was employed, and also appended a few remarks and a record of the result of the treatment. I almost invariably used one of Coxeter's portable combined batteries, so that I had with me either current which might be required.

[Here comes the list, which we do not think it necessary to publish.]

The preceding list does not represent a tithe of the number of patients in the wards on whom electricity was used for one purpose or another during the year, but only includes those for whom my assistance was asked. Several patients, who had been treated by the house surgeons or dressers, were referred to me to continue their treatment as out-patients.

In those cases in which electricity was used for treatment, I think I can show pretty fair success. The first case after my appointment was a woman who suffered from paralysis of the left leg after confinement. She was discharged almost well. The only case of lead palsy I had to treat as an in-patient improved under galvanism. One case of hysteria recovered; the other two did not improve. Of four cases of facial paralysis, two recovered; of one I was only asked to test the condition of the muscles, and the fourth case is still under treatment by the dresser. . . . Of the four cases of infantile paralysis in my list, I was only asked to undertake the treatment of one. This case improved considerably. A second case was treated, after I had seen it once, by the dresser; and of the two other cases I was only asked to test the electro-excitability of the muscles. The two cases of sciatica recovered completely.

In the cases in which electricity was used in the medical wards for diagnostic purposes, it, as a rule, only corroborated the opinion which had been formed from other symptoms, but was most useful in determining cases of supposed or real malingering. But in the surgical wards, where there was paralysis of a limb or part of a limb consequent upon an injury, in some cases, I believe, electricity was of great use in determining, for instance, whether a nerve was completely divided or not, and in other cases in helping to arrive at a decision whether an operation should be performed. I had seven such cases of paralysis following an injury.

In the practice of this department, I have found my former medical and surgical experience of the greatest use, for I have been called upon to examine or treat cases of all descriptions.

For the first few months after my appointment the organisation of the department was under consideration. I therefore did not take under my charge the treatment of the out-patients, except a few cases I was especially asked to attend to. These I find amounted to 74. I shall only give the number treated and the result, as far as I am able to state it, of some of the cases, noting those of more especial interest.

1. *Drop wrist* (13 cases).—Only one could be clearly traceable to lead poisoning. Eight were from pressure on the nerve during sleep, several occurring while the patient was in a state of intoxication. Six of these cases improved. Of the four cases for which no cause could be assigned only one improved. It is impossible to give a very certain opinion as to the result of treatment. Several of the cases had improved considerably and then ceased to attend; I believe they were fairly on the road to recovery.

2. *Loss of power and pain in arms* (12 cases).—Seven of these improved, and in three no benefit was derived. Of the cases which improved, several appeared to be associated with disorder of the menstrual function. One woman, aged 48, sent to me by Dr. Farre, who was passing through her climacteric period, had had pain in both her arms, especially the left, for eighteen months, and had been unable to follow her employment as a needlewomen. After several months' treatment with electricity, she can now do needlework, and the pain has almost disappeared. This woman is still attending as an out-patient; she was induced to attend regularly for so long a time because she had faith in the remedy, and felt better after each application. My experience with these cases leads me to believe that they are certain to be relieved by treatment; and yet I think there is no doubt they suffer the pain of which they complain.

Electricity seems to be particularly useful in all those cases of vague pains and neuralgia which afflict women, and are often called hysterical, and certainly for which no obvious cause can be discovered. The pain appears to be caused merely by some

* We insert this report to show that electrical methods are being carefully examined by those whose privilege it is to attempt the cure of the diseases to which the human frame is liable. There is, we believe, a very large field for the use of electrical apparatus in surgery, and we are glad to chronicle these experiments and results.—*Ed. E.*

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functional derangement, and by no organic lesion, and the application of electricity produces that beneficial change which is repuired to make the organ or its nerves perform their proper function without giving rise to this undue pain.

3. *Facial palsy* (6 cases).—Four cases improved. It was the same with these cases as with others; when they had slightly improved they ceased to attend. In two cases I did not get any beneficial result.

4. *Infantile paralysis* (11 cases).—Six appeared to improve under treatment, five did not. Several that I only saw once I have not counted. The remark with which Sir William Gull commences his article "On the Value of Electricity as a Remedial Agent," in the Guy's Hospital Reports for 1852, is most applicable to these cases, and it shows the difficulty with which an out-patient electrical-department has to contend. He says, with regard to the number of cases he has reported, "They would have been far more numerous had we been able to enforce upon our patients a more regular attendance; but after having carefully recorded the details of their history, progress, and present state, our labour has in more than half the cases been lost by their non-attendance, or by their attending so irregularly, or for so short a time, that no practical inference could be drawn."

5. *Enuresis* (9 cases).—Four were cured, and the other five improved, and would have been cured I believe if they had not, from one reason or another, ceased to come. One woman was pregnant, and I therefore advised her to desist from coming, dreading that I might bring on a miscarriage. One young girl was brought up from the country twice. After the first galvanising she was much better, and I suppose after the second her mother thought there was no more necessity for treatment. In the case of one boy I declined to continue the treatment as he was covered with scabies. I am now treating the scabies.

I have had no cases of amenorrhœa sent to me expressly for treatment, so cannot confirm the good opinion formed by Dr. Golding Bird* and Sir William Gull† as to the effect of electricity in relieving this condition, but several cases I have had to treat in which amenorrhœa was present. The catamenia appeared during the course of treatment, and was marked in several instances by a relief of the paralytic or hysterical symptoms.

6. *Duchenne's paralysis* (1 case).—Did not improve, but got gradually worse; in fact the child, who was about eight years old, became so very weak that I advised the mother not to bring him. He attended for many months, and said he felt better and stronger after each attendance, the relief lasting over the succeeding day.

7. *Paralysis of the serratus magnus* (1 case).—Did not improve. Patient only attended a few times.

8. *Paralysis from division of nerve* (7 cases).—One of these cases was only sent to me to test the muscles, when I was able to show that the median nerve had been completely divided just above the wrist, and the ulnar most likely also partially divided. The other six patients all expressed themselves as benefited by the electricity; but I only saw marked improvement in one.

9. *Paralysis of deltoid* (1 case).—This was produced by a fall on the shoulder. The patient was a sailor, and the accident had taken place on board H.M.S. "Superb" on January 22, 1883. When the patient came to me in August, the deltoid was much wasted. He now (October) can raise the arm with ease and the muscle is recovering its bulk.

10. *Sciatica* (2 cases).—Both cured.

11. *Tic douloureux* (1 case).—This case was sent to me by Mr. Coleman. The pain had been of a most persistent character, and nearly everything had been tried to relieve it but electricity. He improved from the first time he was galvanised, and as he has now ceased to attend, I believe he is cured.

I have made the above selection of the most interesting cases which occurred among the out-patients, but I had numerous others of weakness and numbness, and loss of power in different parts of the body, together with one lunatic and a sprained ankle.

* Guy's Hospital Reports, 1841, p. 114 seq.
† *Ibid.*, 1852-53, p. 137 seq.

LEGAL.

The Jablochkoff Electric Light and Power Company v. Howard and Wyndham.

In the Court of Session at Edinburgh, before Lord Kinnear, evidence was heard on the 16th and 17th instant in this action, which was taken by the Jablochkoff Electric Light and Power Company (Limited) against Messrs. Howard and Wyndham, of the Edinburgh Lyceum Theatre. The purpose of the action was to recover the sum of £1,732 5s. 4d., being the amount said to be due for supplying and fitting up an installation of machinery and fittings for electric lighting at the Lyceum. In defence it was explained that the plaintiffs took over the contract entered into by defendants with the Electric Carbon Storage Company, which went into liquidation. By the contract it was provided that in the event of the apparatus not working satisfactorily, the Electric Company should be bound to remove the machinery at their own cost, and make good any damage. The machinery erected by the plaintiff company was said to be defective, and not in conformity with the contract. Frequent attempts had been made to work the installation, but without success, and the attempts had now been given up as hopeless, the installation being quite unworkable and useless in its present condition. In these circumstances it was pleaded that defendants were not liable in payment of the account. On the other hand, the plaintiffs denied these allegations, and alleged that the installation was complete and in full working order in November, 1883, when it was taken over by defendants without complaint. Several witnesses were called to give evidence as to the insufficiency of the light and as to several failures which had occurred from "earths" being formed, and the case was then adjourned.—Counsel for plaintiffs—Mr. Mackintosh and Mr. Fleming. Agents—Davidson and Syme, W.S. Counsel for defendants—Mr. Trayner and Mr. Lang. Agents—Paterson, Cameron and Co., S.S.C.

The Brush Midland Electric Light and Power Company (Limited).

In the Chancery Division on Tuesday—before Mr. Justice Pearson—Mr. Bucknell supported a petition for the reduction of the company's capital, in accordance with a special resolution passed by the shareholders in November, and confirmed in December last, when it was resolved that in the opinion of the meeting the present nominal capital of the company was in excess of the requirements, and that it should be reduced from £250,000 to £70,500. His lordship, after hearing what was proposed to be done, refused for the present to accede to the petition, but allowed the matter to stand over generally, with liberty to apply to have it restored to the paper.

COMPANIES' MEETINGS & REPORTS.

West Coast of America Telegraph Company (Limited).

The ordinary general meeting of the shareholders was held at the City Terminus Hotel, Cannon-street, on Thursday, Mr. Robinson Kendal (the chairman of the Company) presiding.

The notice convening the meeting was read by Mr. F. L. Robinson (the secretary), and the report and accounts were taken as read.

The Chairman said: Gentlemen—It is now my duty and my pleasure to move the adoption of the report and accounts which you have taken as read, but which I have no doubt have been read elsewhere with satisfaction by most if not all of the shareholders. The Board are pleased to think that they present to the shareholders to-day the most satisfactory and improving balance-sheet the Company has ever had, and whilst we are able to present this balance-sheet we are able at the same time to announce that the Company is still steadily and surely gaining ground, and that good as is last year's report, our receipts for this year show so far an increase of some £7,000. As the report says our earnings for the last year were £57,338 12s. 1d., against the sum of £38,908 2s. 10d. for the previous year—or an increase of £18,430 9s. 3d., and leaving a nett balance, after paying debenture interest and all other charges, of £23,314 9s. 7d.—a result which has fully realised the anticipations of the Board, and firmly established the position of the Company as a dividend paying concern. The significance of this result, and the gratification of the Board, and my own gratification in being able to report it, will be best understood by a reference to our past reports and balance-sheets. Two years ago, owing to the war between China and Peru, and owing to the Chilian Government having cut our cables to prevent the possible transmission of intelligence, our position was far from encouraging, and our prospects far from bright. To meet our engagements we had to mortgage our steamer for between £12,000 and £13,000, and we had a balance on the wrong side of some £20,000. To-day I have the pleasure to say that we have not only paid off the mortgage on our steamer, and extinguished all our indebtedness, but that we have paid in dividends a sum of £12,000, and we are now ready to pay a further sum of £6,000, besides having formed a reserve of some £10,000. These are results which have not been accomplished without much care and anxiety; but

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they are results on which we may fairly and reasonably congratulate the shareholders who have retained their interest in the property, and reaped the reward of their confidence. It will be noted that there is an increase in our expenditure, but the increase in one item, the item which includes the passage out of an extra number of clerks to cope with our increased business, will explain the other increases, which as a consequence follow, and even these increases are unimportant when compared with the increase in our income. Without impairing the efficiency of our service, I hope there will be a diminution rather than an increase in our expenditure as a whole this year; but on this point I would prefer to await the issue and not venture to prophecy. At the moment trade is deplorably bad on the coast, but with the termination of the war, which seems to be approaching, it may be hoped that trade will revive and our Company share in the consequent and general return of business and prosperity. In the ordinary course of things a resumption of trade and business enterprise ought to bring us a still further increase in our income, and help still further to augment our resources, and enhance the reputation of the Company as a solid, successful, and prosperous concern. Our cables are in good condition; they are, in fact, reported to be in as good a condition as when they left the manufacturers. Our staff is efficient for our work, and it will not be the fault of the Board if the Company does not reap the advantage of the future which ought now to be before us. I have pleasure in moving the adoption of the report and accounts.

Mr. T. F. CAMPBELL seconded the motion, and in doing so congratulated the shareholders on the improved position of their affairs.

Mr. LAMONT asked whether the Board had formed any idea as to what amount of reserve was necessary?

The CHAIRMAN replied that the question of reserve had been a matter of calculation and thought on the part of the directors over and over again, and it would still continue to receive their attention. The amount of the reserve would largely depend upon the income of the Company and other matters; but the directors would do all they could to build up the concern on a solid and successful basis, and this could not be done unless they had an adequate reserve.

The motion was then put, and carried unanimously.

Mr. CAMPBELL moved the re-election of the retiring directors, Messrs. Robinson Kendal and Henry Roberts.

Mr. W. E. MACANDREW seconded the motion, which was carried.

On the motion of Mr. TAYLOR, seconded by Mr. LAMONT, Mr. J. Weise (of the firm of Messrs. Turquand, Youngs, and Co.) was re-appointed auditor.

Mr. MASON said that, as the representative of a considerable number of the shareholders, he had much pleasure in moving a vote of thanks to the chairman and directors for their management of the business of the Company during the past year. Their gratitude was especially due to the chairman for his unremitting care and attention to the interests of the Company, for there was little doubt that but for that care and attention the Company would not be in the dividend-paying position which it now occupied. The position of the Company was now very different to what it was in 1879, when Mr. Kendal joined the Board; but although in the interval the amount of business had so very largely increased, the expenses of management were only £500 larger at the present time than they were five years ago. Under the circumstances it was only just that some recognition should be made of the services rendered to the Company by the chairman and his colleagues; and he therefore moved:—"That the best thanks of the shareholders be given to the chairman and directors for their constant attention and devotion to the interests of the Company, and that in view of the inadequate remuneration received by them in the past, the sum of £500 be placed at their disposal out of the funds of the Company."

Mr. TAYLOR, in seconding the motion, remarked that as the original proposer of Mr. Kendal for a seat at the Board, he had watched with the utmost satisfaction the progress which the Company had since made.

Mr. WILKINSON cordially supported the proposition, but suggested that the amount to be voted should be £1,000 instead of £500.

The CHAIRMAN said there had always been the most perfect concord and harmony at the Board, and he had been most ably assisted by his colleagues. Of course the directors would take no part in the discussion of the proposition, and whether or not any money grant was made to them they would feel grateful to the shareholders for their hearty appreciation of the services rendered to the Company by himself and his colleagues.

In the course of some further conversation,

Mr. TAYLOR remarked that since the present chairman joined the Board the market value of their property had advanced from £60,000 to £180,000.

Mr. WILKINSON's suggestion that the amount to be voted should be £1,000 instead of £500 was accepted, and the proposition thus amended was unanimously adopted.

The CHAIRMAN acknowledged the compliment, and the meeting then closed.

Telegraph Construction and Maintenance Company (Limited).

A half-yearly general meeting of the shareholders of this Company was held at the Company's offices, 38, Old Broad-street, E.C., on Tuesday last, under the presidency of Sir Daniel Gooch, Bart., M.P.

The MANAGING DIRECTOR (Mr. Shuter) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, these meetings are merely for the purpose of informing you what progress has been made in our work during the past half year. We have manufactured during the last six months 4,322 miles of cable. We have laid the French cable between Saigon and Tonquin, 785 miles in length, and also the Brazilian Company's duplicate cables between Madeira, St. Vincent, and Pernambuco, amounting to 3,030 miles; and we have effected two repairs in that company's original cables. The steamship "Scotia" is now engaged on a third repair on her way home from the completion of the duplicate lines. The Direct Spanish Company's duplicate cable, 473 miles in length, has been laid between the Lizard and Bilbao. A cable about 40 miles long has been laid across the Strait of Sunda, and sundry lengths have been laid in the Australian and China Seas, amounting to 560 miles. The total lengths laid have been over 4,800 miles. Of course, that has been done under considerable pressure, in order to get it finished in the summer, and you must not expect that the work will continue during the next half year. The year's work is embraced very much in what you have heard me read. With regard to electric lighting, we are now hard at work endeavouring to complete the electric lighting of the Paddington Station. The wires are laid, and it is hoped that by November or December the work will be accomplished. It will enable us to judge how far it corresponds with the estimates that have been made. It is a new line of business entirely for us, and the experiments made there will enable us to draw conclusions as to how far the calculations that have been guiding not only ourselves, but other electric companies, are worthy of trust. I have nothing further to say beyond this, that everything appears to be in satisfactory state.

Subsequently, in reply to a shareholder, the CHAIRMAN said that the accounts were presented at the meeting held in the spring. The present meeting was convened out of deference to the wishes of the shareholders to merely give a statement as to the Company's business.

Mr. WM. ABBOTT reminded the meeting that the suggestion emanated from him that the shareholders should meet every half year with the view of dispelling the rumours that were circulated from time to time by people outside by way of disparaging the Company's property. He thought that every announcement that the chairman made at these half-yearly meetings justified the wisdom of the policy they adopted. He concluded by saying that the shareholders, considering the extraordinary times of depression which they had passed through, could not but express their entire satisfaction as to the condition of the Company and their warm acknowledgments to the Board for the admirable manner in which the affairs of the Company were managed, and he would therefore move:—"That the statement of the chairman to this meeting is satisfactory to the shareholders, and that the best thanks of the meeting be given to the chairman, directors, and the officers of the Company, for their attention to the business of the Company during the past half year."

A SHAREHOLDER seconded the motion, which was cordially agreed to, and

The CHAIRMAN having briefly returned thanks, the proceedings terminated.

The India Rubber, Gutta Percha, and Telegraph Works Company (Limited).

A half-yearly general meeting of the shareholders of this Company was held at the City Terminus Hotel, Cannon-street, on Tuesday last, Mr. S. W. Silver presiding.

The SECRETARY (Mr. Wm. J. Tyler) having read the notice calling the meeting,

The CHAIRMAN said: Gentlemen, our business is very short. We call you together for the purpose of confirming the recommendation of an interim dividend. When we last met, you will remember perhaps that it was to obtain your sanction to apply to Parliament for a short Act to make the Company's memorandum of association clearer and more comprehensive, and I have now to inform you that it received the Royal assent on the 3rd of the present month. Well, now, the chairman—who, I am sorry to say, is at present unwell—told us at the last annual meeting in February that the year had begun satisfactorily. That report I can confirm. The general business done this half year exceeds to some extent that done in any corresponding period of former years. As to our cable orders we have been fairly well employed. We have had several contracts for the Government departments, and for the Western and Brazilian Telegraph Company, which our steamer, the "Dacia," is now, under hire, carrying to the ground. You will be glad to know, with reference to the Spanish National Company's cables, that the obstacles that have hitherto stood in the way are removed by an agreement having been come to between the French and Spanish Governments as to the landing of the Senegal cable at the Canaries; and they have both made us payments under their contracts, and the work is now being gone on with. Well, now, I would remind you that we live in difficult times. The results that I have mentioned have not been arrived at without considerable efforts. As regards general sales, we are well represented in the chief manufacturing centres and at all the leading ports in the United Kingdom. With these few remarks I will now move that an interim dividend of 5 per cent. (or 10s. a share), free of income tax, payable on and after the 23rd inst., be now declared.

Mr. NEIL BANNATYNE: I second that.

The CHAIRMAN, in reply to Mr. Lamont, said that the Company was as well represented in China as it was in any other part of the world, and that the development of the China trade was carefully watched and cultivated by the manager.

The motion was then carried unanimously, and a vote of thanks having been accorded to the chairman and directors for their conduct of the Company's business for the half-year, the proceedings terminated.

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West Middlesex Electric Light Company.

The secretary has forwarded us the following report of the second annual general meeting of this Company, which was held at the Company's offices, Hammersmith, a few days since. As we were not advised of this meeting it was impossible to send a reporter, and we give the following report simply to keep up the continuity of our Companies' Meetings:—Mr. C. Cordingley occupied the chair. He congratulated the shareholders upon the success of the Company in obtaining a provisional order for the Fulham district. The Royal assent was given to the Bill on Monday last, and it now remained for the Company to proceed to carry out the provisions of the order, which were of an extremely satisfactory character. The order practically included the whole of the Fulham district, containing over forty miles of roads. The first installation was not a large one, yet extensions would be made from time to time until the whole district was covered, and this would be carried out under the present order without the expense of applying to Parliament for fresh powers. The first section of the work to be carried out would be from Addison-road railway bridge, through the Broadway and King-street to Rivercourt, with some of the lateral streets; the Cedars estate and Brook-green road. The works for this section were estimated to cost £16,000, and a deposit of £800 only would have to be made to the Board of Trade. Two years was allowed for carrying out this scheme. These were extremely favourable terms, and had been obtained at a moderate cost. Nearly every other provisional order obtained by other metropolitan companies had lapsed, occasioned in many instances by the enormous deposits required by the local authorities. Thus, one company undertook an installation estimated to cost £50,000, and they were required to deposit £25,000. This was fatal to companies. They had numerous applications for the supply of electric light, and with the improvement effected in appliances, tending to economy of production and storage, he believed that the electric light would emerge from the cloud in which it was at present shrouded, and would prove an effective and economical, a healthy and safe light for domestic and other purposes. It was necessary to fill one vacancy upon the board of directors, as Mr. W. H. Lefevre had left the neighbourhood, and did not offer himself for re-election.

Mr. Cosh, in moving that the vacancy upon the Board should not be filled up at present, said that he believed a gentleman of considerable influence would shortly offer himself for a seat upon the Board, and as he was the representative of a large *clientèle* of capitalists, it might be an advantage to the Company to keep the vacancy open. He spoke of the labours of the directors during the past two years, and considered that they had acted wisely in not squandering the capital of the Company in the purchase of patents, many of which had cost other companies thousands of pounds, and were not to-day worth sixpence. They were quite free and unfettered, and could negotiate for the application of the very best system invented up to the present time. The directors had made trials and installations, and examined all the electric light systems in this country. Within a few days they were going to Colchester, in company with Mr. Preece, well known as chief electrician to the Post Office, to inspect the storage system by which that town was lighted, and he hoped that when the works of the Company were complete they would supply Fulham and Hammersmith with an electric light which should be second to none. He traced the difficulties they had had to contend with during the two years of the existence of the Company, commencing with the original agreement with the Board of Works, then the almost insurmountable difficulties which arose through the passing of the Electric Light Act, with the obtaining of the licence, and finally the provisional order. He paid a high compliment to the courtesy of the officials of the Board of Trade, but yet difficulties were daily cropping up in interpreting a new Act of Parliament. These had been boldly met and surmounted. The local authority, from the chairman downwards, had also assisted them in every way, being strongly of opinion that the electric light would prove a great boon to the district.

Mr. Parker seconded the proposition, and stated that the shareholders were well satisfied with the business tact and indefatigable exertions of the Board.

The resolution was unanimously carried, and after some formal business the meeting concluded with a vote of thanks to the directors and chairman.

The Globe Telegraph and Trust Company (Limited).

Report of directors to be presented at the eleventh general meeting on July 29:—The balance-sheet and accounts for the year ending 18th July, 1884, with statement of stocks and shares held by the Company at that date are herewith submitted. The net revenue of the Company for the year, after deduction of expenses, amounts to £189,663 4s., which, with the balance of £1,365 9s. 10d. brought forward, makes a total of £191,028 13s. 10d. From this amount there has been distributed the sum of £131,385 15s. in interim dividends, leaving an available balance of £59,642 18s. 10d. The directors recommend payment of a final dividend for the year of 3s. per share on the preference shares, and of 3s. 6d. per share on the ordinary shares making with the former distributions a total dividend for the year of 6 per cent. upon the preference and 4¾ per cent. upon the ordinary shares, carrying forward a balance of £2,088 3s. 4d. In order to provide the £130,130 to pay required 11,830 new shares of the Eastern Extension Company, taken up last year, and the £15,000 Telegraph Construction and Maintenance Company's 6 per cent. Debentures allotted to this Company, the directors have issued 5,655 preference shares, and 5,655 ordinary shares, and they have also transferred 3,182 of the Eastern Extension shares. The company's balance-sheet is now free from liability of any kind. Forty-four of the shares of the German-Norwegian Company have been drawn and paid off at par, and the proceeds carried to the credit of the capital account. In conformity with the Articles of Association, Mr. William Ford and Sir Daniel Gooch, Bart., M.P., two of the directors, retire, but being eligible offer themselves for re-election. The auditors, Mr. John George Griffiths, F.C.A. (Messrs. Deloitte, Dever, Griffiths, and Co.), and Mr. William Griffith, B.A., barrister-at-law, also retire at the meeting, and offer themselves for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. July 23.		Business Done Week Ending July 23. Highest.	Lowest.
Anglo-American	33,	34	33 1/4	—
Do. Preferred	58,	59	59	57 3/4
Do. Deferred	7 1/2,	7 3/4	7 1/2	7 1/4
Brazilian Submarine	9 7/8,	10 1/8	10 1/8	9 7/8
Cuba	10,	10 1/2	10 1/8	10 1-16
Do. Preference	16 1/2,	17 1/2	17 1/4	—
Direct Spanish	4 1/2,	5	—	—
Do. Preference	14 1/4,	14 3/4	—	—
Direct United States Cable	9 7/8,	10 1/8	10 1/8	10
Eastern Telegraph	11,	11 1/4	11 1/4	10 7/8
Do. 6 per Cent. Preference	13 1/2,	14	13 5/8	—
Do. 5 per Cent. Debentures, 1899	104,	108	106 1/2	—
Eastern Extension	11 3/8,	11 5/8	11 9-16	11 3/8
German Union	9,	9 1/2	9 3/8	9 1/4
Globe Telegraph and Trust	6 3/4,	7	6 7/8	6 3/4
Do. Preference	12 1/2,	12 3/4	12 11-16	12 9-16
Great Northern	13 1/2,	13 3/4	13 3/4	13 9-16
Indo-European	30,	31	30 3/4	—
Mediterranean Extension	1 1/4,	1 3/4	—	—
Do. Preference	2,	3	—	—
Reuter's	8,	8 1/2	—	—
Submarine	160,	165	162	157
West India and Panama	3/4,	1	15-16	—
Do. 1st Preference	6 1/2,	7	6 7/8	—
Western Brazilian	5 3/8,	5 5/8	5 11-16	5 9-16
Western Union 7 per Cent. 1st Mortgage	123,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	106	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	3-16,	5-16	—	—
Oriental	1/8,	3/8	—	—
United Telephone	9 3/4,	10 1/4	10 1/8	9 7/8

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1 1/2,	1 3/4	1 9-16	—
Do. (fully paid)	3,	3 1/2	3 3/8	—
Hammond Light (£3 15s. paid)	3/8,	5/8	—	—
Eastern Electric (£4 paid)	—	—	—	—
Swan	5/8,	7/8	[illegible]	—
Maxim-Weston	1/8,	1/4	—	—

MISCELLANEOUS.

Telegraph Construction	32,	33	32 1/2	32 1/4
India Rubber, Gutta Percha, and Telegraph Works	22,	23	22 7/8	22 5/8

TRAFFIC RECEIPTS FOR JUNE, 1884.

Companies.	June, 1884.	June, 1883.	Increase.	Decrease.
Cuba Submarine	3,150	2,688	462	—
Direct Spanish Telegraph	1,345	1,556	—	211
Eastern Extension	31,787	34,307	—	2,520
Great Northern	22,960	—	—	—
West Coast of America	3,615	—	—	—

WANTED at once, an intelligent MAN, experienced in manufacture of electric light carbons, to take charge of a small Carbon Plant in a factory near London, S.E. district. State experience and wages required.—Address replies, "Coppered Carbon," care of *Electrician*, 1, Salisbury-court, Fleet-street, London.

YOUNG ELECTRICIAN or STUDENT wanted to look after Testing Lamps, &c. Small salary. Hours from 7:30 in summer and 8 in winter.—Apply 36 and 37, Bermondsey-street, S.E.

WANTED.—Steady, sober, LINE MAN, accustomed to Gower-Bell Telephones and Running Wires.—Apply, with references, Engineer, Telephone Exchange Company, Swansea.

CIVIL SERVICE COMMISSION.—EXAMINATION for ASSISTANT EXAMINERSHIPS in the Patent Office (21-25), 29th August. Salary £250 to £400.
The date specified is the latest at which applications can be received. They must be made on forms to be obtained with particulars from the Secretary, Civil Service Commission, London, S.W.

TO ELECTRICAL COMPANIES.—LARGE OFFICES to LET in grand building. Steam, gas, and hydraulic power on the premises. Enquire of G. F. Brooke, Leadenhall Market, London, E.C.

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NOTES.

Book Received.—"La Chaleur et le froid," par L. C. E. Vial. Published by J. Michelet, Paris.

Earthquakes in England.—*Longman's Magazine* contains an article on this subject from the pen of Mr. Richard A. Proctor.

Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ended 25th July were £2,241.

Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ending the 25th inst. amounted to £2,832.

Electric Lighting in Theatres.—The Edison system is now in use on the stage of the Opera House in Paris. Its use was inaugurated a few days since.

Ship Lighting.—It is stated that the lighting of the ss. "Umbria," the new Cunarder, has been entrusted to Mr. Andrews, of Glasgow. The incandescent system will be employed.

Personal.—We are glad to be able to state that Mr. W. H. Preece, F.R.S., has been appointed one of the visitors of Cooper's Hill College, in the place of the late Sir William Siemens.

A Physics Demonstrator Wanted.—The Council of University College, Bristol, want a demonstrator of experimental physics. Applications should be sent in before the 16th August.

Electrical Propulsion of Tramcars.—We understand that the Ryde (Isle of Wight) Pier Company are about to make experiments on the propulsion of their tramcars by electrical energy.

French Electrical Power Storage Company.—A petition for the winding up of this company was presented on the 22nd July by the Faure Electric Accumulator Company, and will be heard by Vice-Chancellor Bacon to-day (Saturday).

Eastern Telegraph Company.—This company announce that the coupons on the Five per Cent. Debentures due on the 1st August will be paid by Messrs. Glyn, Mills, Currie, and Co. Coupons should be left three clear days for examination.

The Sanitas Company.—The directors of this company have declared an interim dividend for the half year ended 30th June last at the rate of 10 per cent. per annum. The business of the company is said to be proceeding most satisfactorily.

Electric Lighting in Belfast.—On Saturday night some experiments were made in the Queen's College, Belfast, in connection with the illumination of the entire buildings with the electric light during the sittings of the British Medical Association.

A Coincidence.—In the "Deaths" column of the *Standard* for the 30th July we noticed the deaths of Mr. John *Lightning* Morgue and the wife of Captain George *Thunder*, a coincidence of two unusual names which we think well worthy of a passing note.

The Telephone in France.—The Minister of Posts and Telegraphs has appointed a commission, composed of ten gentlemen well up in financial matters, to examine into the finances and capabilities of all persons or companies applying to the State for telephonic concessions.

Electric Lighting at Walham Green.—We are requested to state that the arc lamps used at the *fête* of the Butchers' Charitable Institute at Walham Green on the 15th inst., the steadiness of which was commented on, were hired from the Pilsen Electric Light Company.

British Electric Light Company.—A petition for the winding up of this company was presented, in the High Court of Justice, on the 24th July, by Mr. M. W. W. Mackie, of Gracechurch-street, E.C., and is directed to be heard before Vice-Chancellor Bacon to-day (Saturday).

Electric Lighting at Dover.—The arrangements for fitting electric lights in the armour-plated turret on Dover Pier are ordered to be carried out under the superintendence of Captain P. Cardew, principal instructor in telegraphy at the School of Military Engineering, Brompton.

Wimbledon.—The winners in the Telegraph Clerks' Handicap competition at the Wimbledon Rifle Meeting were as follow:—Serg. Kemp, first, 31 points; Serg. Smith, second, 30 points. The first prize consisted of £5, and the second of a cup and £3. The conditions were seven shots at 200 yards.

Domestic Electric Lighting.—We have received a quarto pamphlet entitled "Notes on Domestic Electric Lighting" from the author, Mr. T. Taylor Smith. It contains a description and some excellent illustrations of Mr. Smith's ingenious fittings for domestic electric lighting exhibited at the Health Exhibition.

Earthquake at Massowah.—According to telegrams from Suakin, on July 25, an earthquake had occurred at Massowah. It is stated that nearly all the houses in the town have been destroyed or damaged by the shock. The ships in the harbour were seen to rock violently. The inhabitants were greatly alarmed, and fled to the mainland.

Business Notice.—We understand that Mr. Harry South, who, until recently, was associated with the Hammond Electric Light and Power Storage Company, and at various times had charge of several of their most important installations, has commenced business as an engineer and electric light contractor, at 169, Queen Victoria-street, London, E.C.

Post Office Telegraphs.—Examinations for female telegraph learners in the General Post Office at London and Dublin will shortly take place; that for London on the 17th Sept., and for Dublin on the 9th August. The ages of candidates must be between 14 and 18. Further particulars can be had of the secretary, Civil Service Commission, London, S.W.

Telegraphic Extension in Scotland.—The new line from Lochboisdale to Barra was commenced last week. A number of men are busily engaged erecting the poles between Dalibrog and Polashar. The steamer for laying down the cable between the farm of Kilbride and Bravig Bay—a small bay some two miles north of Castle Bay, Barra—arrived on Saturday.

Electrical Transmission of Power.—A French contemporary says that the preparations for M. Deprez's experiments on the transmission of power between Creil and Paris are being actively carried on. The preliminary work is finished, and the two engines which are to supply the motive power are already in place at Creil. The collectors of the electrical machines are being constructed by the firm of Gottendorf.

Electric Railways in America.—The *Standard's* New York correspondent, telegraphing on Tuesday, said:—"Litiga-

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tion in respect to patent rights has hitherto impeded the development of electric railways. The Patent Office has now decided in favour of S. D. Field against Edison and Siemens. The first railway was opened at Cleveland, Ohio, on Saturday, and others are expected to be constructed now in quick succession."

THE MAGAZINES.—We have on our table *Cassell's Magazine* for August, and the same firm's "Technical Educator," Part 6. The former contains the continuation of several interesting stories, and the columns of "The Gatherer" include many electrical items. The latter has instructive and well-illustrated articles on "Notable Inventions and Inventors," "Technical Drawing," "Building Construction," "Applied Mechanics," "The Electric Telegraph," &c.

TELEPHONY.—Servia boasts 1 telephone line 1 kilometre long, connecting the Ministry of the Interior and the Prefecture at Belgrade. Bulgaria and Luxembourg do not believe in the telephone; at all events, they have not a yard of line at work at present. Turkey has three lines, one used by the Administration of Telegraphs, the second used at a life-saving station on the Black Sea, and the third belonging to the Eastern Telegraph Company and the Ottoman Bank. The above lines represent a total length of wire of 41 kilometres.

EXHIBITION AT VIENNA.—An international exhibition of motors and tools has been opened at Vienna. Its object is to promote improvements and the development of small trades by showing how they can compete with large manufacturers. All the new appliances in lighting will be exhibited, including two great Siemens regenerators. Gas burners of 2,000 candle-power each are placed in the gallery of the main hall, and other rooms will be illuminated by incandescent and arc lamps, and by gas lamps of various construction. Several English firms are among the exhibitors.

THE LATE SIR WILLIAM SIEMENS.—The executors under the will of the late Sir William Siemens, F.R.S., &c., announce that they have arranged for the continuance of Sir William Siemens's practice as consulting engineer, by transferring his obligations and rights, including his patents for regenerative gas furnaces, and iron, steel, and glass processes, to his brother, Mr. Frederick Siemens. They add that the business will be conducted on precisely the same lines as heretofore, and Mr. John Head, who was the representative and principal assistant to Sir William Siemens, will continue to act in the same capacity for his brother.

A MULTIPLYING SEISMOGRAPH.—At the last meeting of the French Academy of Sciences M. Bouquet de la Grye communicated the results he had obtained at Puebla with a multiplying seismograph. The friction of the parts of this apparatus is so small that the heat of the hand produces a movement of the indicating needle. Results obtained during November and December, 1882, show that the sun and the moon have a direct action on the pendulum. The moon attracts it, the sun has an inverse effect. By its means 22 abnormal movements were noted during one month, which were probably due to seismic causes. One of them only was felt in the town of Puebla.

REDUCTION OF PATENT FEES.—The Board of Trade, with the consent of the Treasury, have made the following reduction relating to certain fees prescribed by the Second Schedule of the Patents, Designs, and Trade Marks Act, 1883:—In the case of patents granted before the commencement of the said Act a patentee who has paid the prescribed fee of £50 before the end of four years from the date of his patent may, in lieu of the prescribed fee of £100, payable before the end of seven years from such date, pay the following annual fees:—Before the end of the seventh year from the date of the patent, £10; eighth, £10; ninth, £10; tenth, £15; eleventh, £15; twelfth, £20; and thirteenth, £20. This reduction came into operation on the 1st of this month, viz., Friday.

THE CLAIMS OF THE TELEPHONE COMPANIES.—In the House of Commons on Thursday week Mr. Fawcett said, in answer to Mr. Jacob Bright, that the United Telephone Company and another company had submitted to him proposals involving very complicated and difficult details. It was of great importance that these should be considered in all their bearings. Although he had personally devoted all the time he could spare to it, the investigation was not yet completed. Several companies had not yet sent in proposals, and they had been informed that if they did not do so he would give his decision without them. No one could be more anxious than he was that a speedy settlement of the question between the Post Office and the telephone companies should be speedily settled.

HONOURS FOR AN ELECTRICIAN.—The Paris correspondent of the *Daily News* says:—"English electricians who were connected with the Paris Electrical Exhibition organised by Dr. Cornelius Herz in 1881 will hear with pleasure that he has been, upon the proposition of the Minister of Posts and Telegraphs, raised to the grade of Commander of the Legion of Honour for services rendered to electrical science. Dr. Herz is known in France, and has supplied for a number of years the funds required for making costly experiments in the transmission of power by electricity and enabling inventors to carry out their conceptions. He founded *La Lumière Electrique*, the leading specialist organ in France. Dr. Herz, though born in France, is of American nationality, and the only foreign scientific man who has ever been made Commander of the Legion of Honour."

TELEGRAPHING MONEY ORDERS.—Great improvements in the money order system of India will, says *The Times*' Calcutta correspondent, be introduced on October 11, the German system being closely followed. Coupons will be added to the orders, on which the remitters may communicate their wishes to the payees. Payment at the payee's residence will also be arranged for; and telegraphic money orders will be introduced at a charge of 1 per cent., plus the cost of the telegram.—Mr. K. B. Murray takes the opportunity afforded by the publication of the news to write to the *Daily Chronicle*, pointing out that, although such a system has been mooted several times at the General Post Office, it has always, up to the present, been regarded with disfavour. He hopes that the example of India may spur our own authorities to try and overcome the technical difficulties surrounding the matter.

COST OF ELECTRIC LIGHTING.—The *Bulletin* of the Compagnie Internationale des Téléphones says:—"We have received a communication, giving the working cost of the electric lighting installed by the Société Edison in the grocery shop of Felix Potin. This lighting cost for one month, 6th March to 6th April, 1884, 367·15f., distributed as follows:—Wages, 150f.; lubrication, 1 kilo of olive oil per diem, or 26 kilos per month, at 2·66f., 69·15f.; eight lamps, at 6f., 48f.; coal, 100f. —total, 367·15f. The installation comprises 71 incandescent lamps, burning 12 hours per day. The number of hours of lighting was therefore 852 per day, or 28,152 for the month. The lamp hour costs, therefore, 1·7 cent. Further, 3,102 cubic metres of gas were saved, the amount consumed in the same month of the previous year, which at ·30f. would have

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cost 930·60f. Deducting from this sum the 367·15f. expended on the Edison light we have an actual saving of 563·45f.

OVERHEAD WIRES IN LONDON.—Sir H. Tyler has made an interesting calculation, from which he finds that no less than 230 overhead wires may be counted between the Royal Exchange and St. Michael's Church, Cornhill, and 200, more or less, between the Mansion House and Queen-street, the latter being stretched across Queen Victoria-street. A few days since he called the attention of the Secretary of the Local Government Board to these figures. In his reply this gentleman pointed out that out of the 230 only six belonged to the Post Office, and out of the 200 only four. He further stated that it was under consideration whether a Select Committee of the House of Commons should be moved for next Session, to inquire into and report upon the subject of overhead wires. We have recently seen it stated in a contemporary that "overhead wires serve to dissipate the electricity in the atmosphere, and thus protect cities from lightning." Do they ? We should be glad if the paper in question would kindly substantiate its statement.

THE NANTUCKET CABLE.—The Boston (Massachusetts) *Herald* of July 16 says :—The appropriation of 20,000 dols. by Congress for the establishment of a signal station at Nantucket and the laying of a cable connecting the island with the main land causes great rejoicing. It is believed that in the fall an additional appropriation will be secured, and that before the winter is over the island will enjoy the blessing of direct communication with the Continent. No place of similar size on the Continent is so isolated from the outside world during the winter season. The boats from Woods Holl run irregularly, owing to the uncertainty of the weather, and many a person who has ventured to go to the island in the winter season has remained a prisoner there for a week or more, deprived not only of means to get away from there, but of means to communicate with his family and friends. There are many wrecks off the shore of the island, and oftentimes a long time must elapse before the details are known. The value of a cable as a means of transmitting shipping news can hardly be overestimated.

LONDON LOCAL AUTHORITIES AND OVERHEAD WIRES.—The Parliamentary Committee of the Lambeth Vestry reported at the last meeting of that authority that they had considered the application received from the Board of Works for Wandsworth, asking that the vestry should contribute towards the expense of appealing to the House of Lords against the judgment of the Court of Appeal in the action brought by the Wandsworth District Board of Works against the United Telephone Company for erecting overhead wires in the Wandsworth district. The Court of Appeal having given a unanimous judgment against the rights of the local authority to restrain (except where actual danger was shown to be likely to arise) wires being placed across the streets of the parish, the committee did not advise the vestry to contribute towards the costs of the appeal or to support the Wands worth Board ; but the committee recommended the vestry to join with the Marylebone Vestry in urging the Government to pass a Bill through Parliament conferring upon the local authorities the control over the erection and maintenance of overhead wires. The recommendation was carried.

THE TELEPHONE AND THE POST OFFICE.—In the House of Commons on Tuesday last Mr. Gray asked the First Lord of the Treasury whether he was aware that, although the House had refused to give to the Post Office control over the telephones, the department obtained a legal decision on a technical point, to the effect that a telephonic message was a telegraph message and within the meaning of the Act of 1869, although at the time the Act was passed the telephone was not in existence ; and whether he was aware that since that date the Post Office had levied a tax upon the use of the telephone, and had imposed constantly increasing restrictions, eventually amounting to practical prohibition of its use for exchange purposes ?—Mr. Gladstone stated that a judgment had been taken in the courts as to the sufficiency of the existing law for the protection of the Post Office, and according to the legal advisers of the Government that decision by no means rested on a technical point, but upon the substance of the matter. It was to the effect that the Crown was in possession of certain rights by the existing law, and, that being so, it was the duty of the department to assert those rights. As to the amount of the tax, he was not prepared to say what should be the proper position of the Government, but his right hon. friend the Postmaster-General was engaged in considering whether, with justice to the Crown, he could relax the rules now in force.

OUR TORPEDO SERVICE.—The following notification has been published :—The Admiralty are giving increased attention to the importance of torpedoes in naval warfare, whether carried in independent small craft or on board of men-of-war, and have just issued an order for the purpose of securing uniformity in the arrangements of all torpedo fittings and electric apparatus in Her Majesty's ships. As the only place possessing torpedo schools ashore as well as afloat, and an electrical workshop and a staff of officers, Portsmouth has been very properly converted into the head-quarters for the torpedo branch of the service. There all the patterns and drawings of approved fittings are for the future to be prepared, whence, with the necessary instructions, they are to be forwarded to the other dockyards for the guidance of the officers concerned. The dockyard officers at Portsmouth are to confer with the captain of the "Vernon" on all questions relating to changes of existing patterns and to the introduction of fittings for new classes of ships and boats, and once every week the latter is instructed to attend the *levée* of the Admiral-Superintendent for the purpose of considering any matter which may arise in relation to torpedo and electric fittings. It is also ordered that the position of all electric batteries and machines, projectors, and directors, and the stowage of torpedo stores, &c., are to be arranged in consultation with an officer from the department of the Director of Naval Ordnance, the fittings being carried out by the dockyard. Tracings of all proposals are to be forwarded to the Admiralty for approval before being undertaken, and after the work has been supervised by an Admiralty official and tested when completed by another, previous to the ships being passed into the first division of the steam reserve, no alteration is to be made without the sanction of their lordships.

EARTH CURRENTS.—The *Journal Télégraphique* gives a translation of an article from No. 5 of the *Maanblad voor Telegraphie* for 1884, by Mr. Hissink, of the Dutch Indian Telegraph Service, from which we take the following :—"We observed very strong earth currents on the 17th, 20th, and 21st April, 1882, traversing the line which unites Lahat (Island of Sumatra) and Benkoelen by way of Tebing Tinggi. The length of this line is 220·73 kilom., and its resistance 970 ohms. On the 17th April the earth current appeared directly the daily work was begun, at 8:55 a.m., and from time to time telegraphic communication was interrupted up to 4 p.m. The currents were particularly strong from noon to one o'clock. The needle of the Siemens sine galvanometer included in the circuit to

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Lahat gave all kinds of deflections, now − 65°, now + 45°. The current varied at long intervals and each time changed direction. The two other lines going from Lahat to Moearadoea and Palembang, which ran in a different direction, were only traversed by weak earth currents. On the 20th April we again observed more or less strong earth currents traversing the same line between Lahat and Benkoelen. The galvanometer indicated from 9 a.m. to 9:15 a.m. a deflection of + 15 to + 25; at 11:25 this became − 37; at 11:50, + 27; at 12:8 noon, + 15; at 12:10, − 5; at 12:14, + 3. Later on the current varied every moment; the greatest deflection, that of − 49, was observed between 2:30 and 3 o'clock. The current then flowed without interruption in a direction from Benkoelen to Lahat. Communication with Tebing Tinggi office was occasionally interrupted. On the morrow we made similar observations up to 3 o'clock. Later on we found that the wire between Benkoelen and Tebing Tinggi had been broken at eight leagues from Benkoelen; but the deflections of the needle and the other observations made enabled us to ascertain that the line was affected by earth currents."

Gas and Electricity.—We think the following extract from an address delivered last week by Mr. F. T. Linton, engineer to the Edinburgh and Leith Gasworks, as president of the North British Association of Gas Managers, well worthy of a place in our "Notes." Speaking of the prospects of gas lighting, he said:—"How far other sources, and notably electricity, might come into use as competitors for illuminating purposes with coal gas they need not discuss. The hard logic of facts had shown how impossible in present circumstances it was for electric lighting to compete commercially with gas, and it was difficult to conceive any probability of those circumstances being materially altered. Meanwhile they, as humble fellow-workers in the same field of adapting the forces of nature to the use and benefit of mankind, might well express their unfeigned admiration for that most beautiful and striking example of it which the genius and patient labour of many eminent men had produced in the various forms of electric lighting, and especially in the incandescent lamp. They had no jealousy of the electric light. They wished it every success in the many special uses to which it was admirably adapted. They did regret, however, that, owing to the action of unprincipled speculators, and, it must be added, to the way in which the public press in too many instances lent itself to the publication of extravagant and misleading statements, the legitimate extension of the use of electric lighting had been hindered for probably many years, and the money of a number of credulous persons, to the extent of millions of pounds, absolutely squandered. It seemed to him that gas manufacturers, who were threatened, somewhat jubilantly on the part of some people, with total extinction by electric lighting, were, after all, those whom it had chiefly benefited. They must confess that it was largely due to the threatened competition by electric lighting that their profession had been thoroughly roused from a condition of use and wont to one of activity and progress, and that spirit of inquiry induced which had already led to such beneficial results." We are glad also to be able to record the fact that Mr. Linton's sentiments were most cordially received by his audience.

Electric Lighting in London.—The Board of Trade have decided to proceed at once to revoke no fewer than 25 of the provisional orders which were granted by them last year, and subsequently confirmed by Parliament, for the electric lighting of London and its suburbs. Of this number 23 are orders which were obtained by the Metropolitan Brush Electric Light and Power Company, which has since gone into liquidation. These orders relate to the electric lighting of Barnes, Mortlake, Bermondsey, Chelsea, Chiswick, Clerkenwell, Finchley, Greenwich, Hackney, Holborn, Hornsey, Islington, Limehouse, Poplar, Rotherhithe, St. George's-in-the-East, St. George the Martyr, portions of the parish of St. Giles, the parishes of St. Luke's, St. Olave, St. Saviour's, Southwark, Shoreditch, Whitechapel, and an order known as the Wandsworth order, which, however, relates to portions only of the parish of Clapham. Of the other two orders which will be revoked one relates to the lighting of Kensington, and the other is an order granted to the Pilsen-Joel Electric Lighting Company, with powers to light those portions of the parish of St. Giles not granted to the Metropolitan Brush Company. So far as London is concerned, the result, therefore, of the numerous electric lighting orders which have been granted during the past two years is that only eight now remain in force, namely, the St. James's and St. Martin's order, which, with the Hanover-square, Strand, and Victoria district orders, are now held by the Edison and Swan United Electric Lighting Company; the Hampstead order, granted to the Hampstead Electric Lighting Company; the St. Pancras order, granted to the Vestry; the order for the lighting of Fulham, which was granted only last May to the West Middlesex Electric Lighting Company; and the order, also granted in May last, to the West London Electric Lighting Company, for lighting portions of the parishes of St. George's, Hanover-square, St. James's, Westminster, and St. Martin-in-the-Fields. Of these eight orders, the first five have already had their time extended within which to comply with the provisions of the orders, and unless these provisions are complied with before the 15th October next, the powers will be lost, unless a further extension of time is granted.

Thunderstorms.—The latter end of last week was marked by a series of more or less severe thunderstorms in the British Isles. At Burwell, near Whitney, Oxon., on Thursday, the 24th July, a cow was killed. A thunderstorm also passed over Oxford on the same afternoon, but without, so far as we know, doing any damage. A storm visited London on the same date, and was remarkable for its severity and short duration, although no damage appears to have been done. At Sunderland a clerk of Messrs. Austin and Son, shipbuilders, was struck by lightning while listening to a telephonic message. He fell to the ground and was seized with violent hysterical fits. He was subsequently seen by Drs. Morgan and Horan and conveyed to the infirmary, where he is reported to be going on well. At Nottingham, James Harris, a milkman, whilst selling milk to some men employed upon a new sewer at the east end of the town, was struck by lightning, which set fire to his hair and passed down the left side of his body as far as his heel, causing instant death. At Dedisham Farm, in the parish of Slinfold, five valuable cart horses were struck by lightning and knocked down. Three of them were killed, another was struck blind, and the fifth was injured, but not permanently. Two boys were knocked down at the same time, but escaped serious injury. At Tunstall (Staffs.) a chimney of the manufactory of Mr. Holcroft was struck by lightning, which passed into a workshop where several women were employed. The windows were smashed, but the women were not injured. At Warminster 12 cows, standing near some iron fencing on the farm of Mr. George Pickford, of Monckton Deverill, were struck dead by the lightning, and two others were also so badly mutilated that they had to be slaughtered. Scotland was also visited on the same day, viz., Thursday, the

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24th July, by severe storms. At Arbroath the tower of the Memorial Chapel, just erected in the cemetery by Mr. Allan Fraser, of Hospital Field, was struck by lightning, but the damage done was trifling. Two masons were standing in the main doorway at the time, and were stunned. The lightning was attracted by a steel rope of a tramway used for the carriage of building materials up Keptie Hill to the new water works. It passed along the rope, and Mr. Archd. Anderson, contractor for the works, who was standing near, was stunned, temporarily losing the power of one of his hands. He soon recovered, however, as did also the two men at the cemetery. All the reports speak of the storms as having been accompanied by unusually large hailstones. On Saturday, the 26th of July, during a slight thunderstorms which passed over the Lake district the corning-house at the Black Peck Powder Mills, near Ulverston, was struck by lightning. A terrific explosion ensued, completely wrecking the building and killing three men who were inside at the time instantaneously. Another, named George Gosten, was standing outside, and the flames from the explosion set fire to his clothing, but by throwing himself into an adjoining brook he escaped with a severe scorching. Those killed were John Woodend, aged 60, single; Reuben Stephenson, aged 35, married, four children; and William Phillips, aged 23, married, one child.

THE ELECTRIC LIGHTING ACT.—Our very enterprising contemporary, the *Pall Mall Gazette*, has been interviewing Mr. Arnold White, late of the Edison Company, on the subject of the Electric Lighting Act. Mr. White has already made our readers aware of his sentiments in this matter, and we shall therefore make only a few extracts from the report of this interview. The failure of the Act, Mr. White thinks, "arises primarily from comparing the gas burner, which consumes something physical—namely, gas—with the incandescent lamp, which gives something infinitely more subtle—namely, a form of energy. The cardinal principle running through the Act, and which vitiates it, in my opinion, is the treatment of electricity as though it were treacle or butter; as though it were powderable, and could be sold in quantity, while it is obvious that electricity is only known by its effects in light, heat, or power." When asked by the *Pall Mall* reporter if he had ever made an analysis of how the millions subscribed for electric lighting have been spent, Mr. White replied, "Yes. In 1882 there were sixty-two companies founded, the paid-up capital on which was £4,951,575. Since then about £400,000 has been called up, giving a total of £5,351,575 as the amount actually invested since 1882 in the electric lighting enterprise under the Joint Stock Companies Act. I estimate the expenditure of this amount during the past thirty months to have been as follows:—

	£
Promoters, including "patents"	800,000
Inventors	115,000
Law and Parliamentary charges	160,000
Directors' fees	130,000
Expended on exhibitions and free lighting, undertaken for advertisement	300,000
Expended on machinery and plant, now mostly obsolete	270,000
Expended on installations and ship lighting, undertaken mainly at a loss	1,000,000
Fixed charges, *i.e.*, clerks, secretaries, office rent, advertising, and sundries	1,250,000
Cash in hand	500,000
Factories, plant, and stock	826,575
	5,331,575

I do not believe that as a going concern the electric light interests now in the hands of the joint stock companies are worth in the aggregate more than a million sterling, and I question whether the profits on the business as a whole would yield 5 per cent. dividend on that amount. In support of this opinion I may mention that the paid-up capital of those electrical companies which have obtained a quotation on the London Stock Exchange amounts to £1,289,000, while, at the price quoted in the official list of Saturday last the whole could be bought for £221,880."

ELECTRIC LIGHTING FOR LAMBETH.—At the last meeting of the Lambeth Vestry, Mr. Fowler brought forward a report of the Electric Lighting Committee, stating that, after waiting several months, in lieu of the draft licence settled by counsel on behalf of the Vestry and submitted to the Board of Trade for their approval, the Board had written sending to the Vestry a form which had been settled for Colchester, and suggesting that the vestry clerk should alter the form to make it applicable for Lambeth. To this the clerk replied that the form for Colchester was not a form for the local authorities at Colchester, but for a private company; that the form did not appear applicable to a local authority taking a licence; and suggested that the Board of Trade should consider the form already before them settled by counsel for Lambeth. In the result an interview had taken place at the Board of Trade between the vestry clerk and Mr. Calcraft, the Board's secretary, accompanied by the Board's counsel, Mr. Meysey Thompson, at which Mr. Calcraft produced a print of a new form of licence for Lambeth, which was given to the vestry clerk for him to consider, and it was at the same time arranged that should the Vestry not accept the licence in the new form, the counsel of the Board and the counsel of the Vestry should meet to see whether the differences could not be adjusted. On referring to the new form it was found that it was word for word the same with the licence given to the private company for Colchester, making only the necessary alterations, except that the form gave to the Metropolitan Board of Works the powers as a local authority, which, by the Colchester form, was given to the local authority for Colchester, although in Lambeth the Vestry and not the Metropolitan Board is, by the 31st section of the Electric Lighting Act, made the local authority. In the form the stringent provisions which might be properly imposed on a private company, but which were not required, and were quite inapplicable in a licence given to the local authority, were all retained. The committee, after fully considering the matter, recommended that the Vestry should send to the Board of Trade a memorial, praying that the licence might be granted in its original form; that the Board might receive a deputation from the Vestry in support of the memorial; and that the borough members be asked to attend the Board with the deputation in support of the views of the Vestry. Mr. Fowler, in moving the adoption of the report, said the committee had been very anxious to obtain a licence, because they felt that a great improvement might be made in the lighting of the parish; and if not universally adopted, there were portions of the parish which would readily accept the light. The Board of Trade, however, sent back the licence, and presented them in its stead with a licence prepared for a public company, with very stringent conditions attached. These it was impossible for them to accept. Therefore the committee wished to appeal to the Board of Trade by deputation, because they were convinced the Vestry would regret that the light should be carried out by stealth, as in the Brixton-road, rather than under the direct surveillance of the Vestry. The resolution was carried, only one hand being held up in opposition.

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THE ELEMENTS OF ELECTRIC LIGHT ENGINEERING.

BY E. C. RIMINGTON.

Before commencing to set up a dynamo machine and arrange a circuit it is necessary that the reader should be acquainted with the various forms of instruments for measuring current and electromotive force.

In putting up a circuit the current flowing through it, or, in the case of a multiple circuit, through each branch of it, should be known.

Most instruments for measuring strong currents as produced by dynamo machines are simply modifications of galvanometers, where the current is made to pass round a magnetised needle, which it deflects.

The simplest form of galvanometer, which gives readings proportional to the currents passing through it, is the tangent. This instrument is, in its ordinary form, fitted with two turns of thick copper rod to take large currents; it has to be placed in the magnetic meridian so that the needle remains at zero when no current is passing through it. The scale is generally divided into natural tangents, so that the current is proportional to the number of divisions indicated by the pointer or needle; when, however, the scale is only divided into ordinary degrees of arc, the current is proportional to the natural tangent of these degrees.

Other forms of measures for strong currents are made after the manner of ordinary galvanometers, but the magnetic needle is placed between the poles of a very strong permanent magnet, thus allowing the instrument to be employed in any position. The number of degrees indicated by the pointer are read off, and are given in amperes by reference to a table, usually supplied with the instrument. Among these may be mentioned M. Deprez's ampere meter and Messrs. Ayrton and Perry's modification of Deprez's instrument.

Another and different form of current meter is Siemens's electro-dynamometer, which acts by the well-known law that currents flowing in parallel wires in the same direction attract one another, the force with which they attract one another being neutralised by the torsion of a fine brass spring. The last instrument can be employed with alternating currents, an advantage which none of the before-mentioned instruments possess; its great disadvantage being that it is a zero instrument, and therefore only suitable for a fairly steady current.

Instruments for measuring E.M.F. are similar in form to those for current, the difference being that, while the latter are wound so as to have as low a resistance as possible, the former have a resistance of from 2,000 to 10,000 or more ohms, so that a *very* small current flows through them.

Dynamos may be divided into five classes, viz.,

(1) Magneto dynamos.
(2) Separately excited dynamos.
(3) Series dynamos.
(4) Shunt dynamos.
(5) Compound dynamos.

The first class consists of an armature rotating between the poles of one or more permanent magnets; but, as this form of dynamo is now so seldom seen or used, we shall say no further concerning it.

We will now give a description of the series dynamo (3) as related to the external circuit, leaving the separately excited machine for future consideration:—

The Series Dynamo.

This machine is the cheapest and most generally employed form of dynamo, especially in the case of arc lighting. It is essentially composed of an armature, A, Fig. 1, wound with insulated copper wire, and provided with a collector, C; this armature is rotated in the magnetic field produced by the field-magnets F M.

The current generated in the armature by its rotation is collected by means of brushes, B B, of wire or slit metal, which press lightly against the collector C.

T and T_1 are the terminals of the machine, to which the external circuit is attached.

This form of dynamo is termed "series," because the armature, field-magnets, and external circuit are all in series with one another. Fig. 2 shows clearly how this is arranged, the letters representing the same parts as those in Fig. 1. From this it will easily will be seen that the armature A, the field-magnets F M, and the external resistance R form one unbroken circuit. The current generated in the armature A, by its rotation in the magnetic field, passes by the brush B, which we will call the + or positive brush, round the field-magnets F M, through the external circuit R, and back through the – or negative brush B, to the point whence it started.

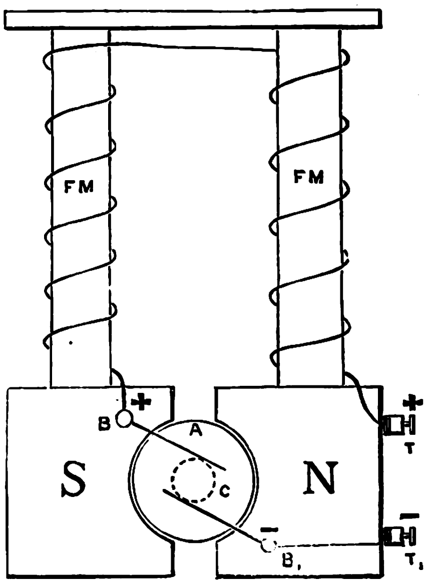

Fig. 1.

The series dynamo is self exciting—that is to say, on rotating the armature a very small current is started by the residual magnetism remaining in the field magnets (the iron of which they are made being never soft enough to completely lose all its magnetism). This small current, flowing round the field-magnets causes them to become more magnetic, and produce a stronger magnetic field, which in its turn produces a stronger current, thus making the field-magnets still stronger, and so on. This action, though it takes time to describe, occurs practically almost instantaneously. In running a new machine it sometimes happens that there is not sufficient residual magnetism in the field-magnets to start any currrent. In this case the machine should be circuited through a low resistance, say from ½ ohm to 1 ohm, or *very cautiously* short-circuited for a few seconds (in the latter case it is *advisable* to keep out of the way of the driving belt in case it should break from the sudden strain caused by the strong current produced). If there is no trace of residual magnetism in the magnets this method will fail, and it will then be necessary to stop the machine and connect a few battery cells to the terminals for a short time.

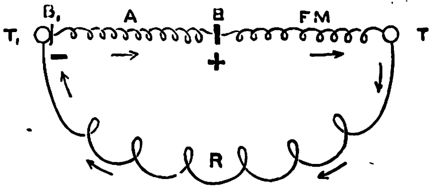

Fig. 2.

We shall now give a short description of the various forms of armatures employed in continuous current dynamo machines, but although they are given as related to the series machine they apply equally well to the armatures of any machine giving a continuous current, whether series, shunt, separately excited, or compound.

Armatures may be divided into three classes:—

(1) Ring armatures.
(2) Drum armatures.
(3) Pole armatures.

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The last class of the three being seldom employed in continuous current machines we shall not yet touch upon it. Ring armatures are composed of wire coiled upon a ring, the principal armature of this type being the Gramme. In the case of the Gramme armature the ring is composed of iron wire, the insulated copper wire being coiled round and round it, as in Figs. 3 and 4, wires being brought from every few coils, as shown, to adjacent strips of the collector.* In practice the wire is not coiled all in one length, but in separate coils, one end of each of which is attached to one strip of the collector, and the other to the next strip, to which is also connected the first end of the next coil, as shown in Fig. 4. Each coil is, however, composed of several layers of wire, the number depending on the fineness of the wire employed in winding, dynamos for high electromotive force and small current having a large number of turns of fine wire in each coil, while those for low electromotive force and large current have fewer turns of thicker wire. There are various modifications of this method of winding, as regards the shape of the section of the ring, but the same principle is involved in all of them.

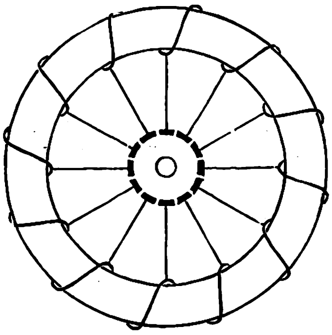

Fig. 3.

Drum armatures are composed of wire wound longitudinally round a drum made of wood or iron. One end of one coil is connected to one segment or slip of the collector (which is of the same form as that employed for the ring armature), the other to the next slip, to which is also connected one end of the next coil, and so on, as in the case of ring armatures. The drum armature is employed in the Siemens direct current, in Edison's, and in other machines.

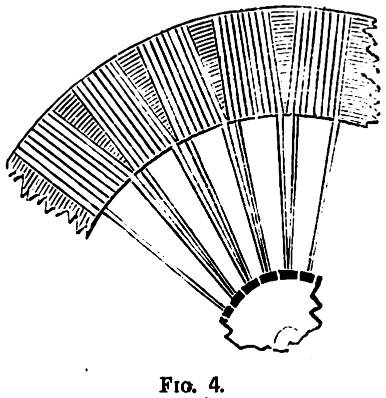

Fig. 4.

Although the field-magnets of a series dynamo are often arranged as in Fig. 1, this is by no means the only method of arrangement. The armature may come between the coils of the two field-magnets, as Fig. 5 and Fig. 6, where the current generated in the armature flows by the brush B through the field-magnet F M to the + terminal T, thence through the external circuit R and back, through the field-magnet F M, to the armature by the – brush B_1, as shown by the arrows in Fig. 6.

The first operation to be performed when we have a new and unknown dynamo to deal with is to measure its internal resistance—*i.e.*, the resistance through the terminals, and the resistance of the field-magnets and armature.

* Sometimes miscalled commutator. The Brush and the Weston-Plating dynamos are about the only machines that have a *commutator*.

To do this we employ a Wheatstone bridge, the principle of which will be found in any text-book on electricity.

The method of working a bridge to measure some fixed resistance is as follows:—

We have four terminals, D F E H; between D and F is connected a resistance A, between D and H another resistance B, between H and E another, R; between F and E is inserted the unknown resistance to be measured (in this case the dynamo machine, the terminals of which, T and T, are connected to F and E); between F and H is inserted a galvanometer, G, and a key, k, to connect or disconnect the galvanometer from H.

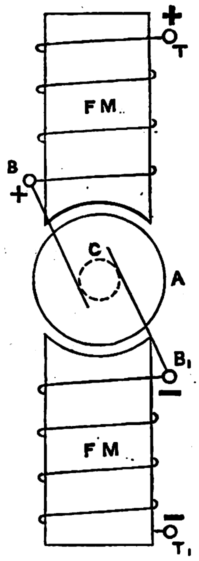

Fig. 5.

To D is attached one pole of a battery of two or three cells, while the other pole is connected to E through the key k.

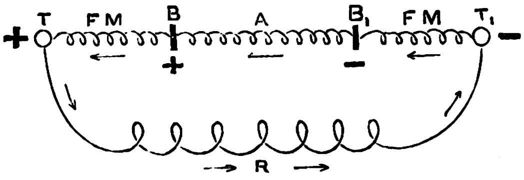

Fig 6.

The resistances A and B are kept constant, while R is varied. For measuring a series dynamo we may make A = 10 ohms, B = 100 ohms.

Suppose we have a bridge thus connected up. Unplug in R some resistance at random; depress the key k, then, after two or three seconds, depress k_1, keeping k still depressed. We shall now probably obtain a deflection on the galvanometer G either to the right or to the left, for it is improbable that we should have chosen R of exactly the right resistance; suppose we obtain a slight deflection to the right. Now, to find whether this deflection is due to R being too large or too small, make R infinite by pulling out the infinity plug, or by disconnecting it either from E or H, and again depress the key; there is now a violent deflection one way or the other, say to the right.

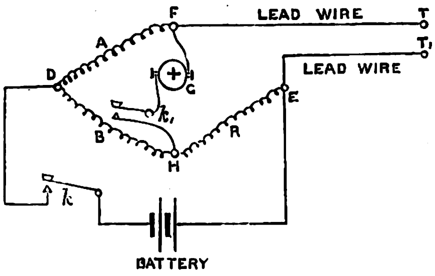

Fig. 7.

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We therefore now know that a deflection to the right means that R is too large, and, *vice versâ*, one to the left shows it to be too small. Connect R again to E and G as before, but slightly lessen its resistance; depress the keys as before. Suppose we now obtain a smaller deflection to the right, we must decrease R until on depressing the keys no deflection is seen on the galvanometer; if, however, a deflection to the left is obtained, R must be increased.

When a balance is obtained—*i.e.*, when the galvanometer gives no deflection on depressing the keys, the resistance of R must be noted. Then the resistance of the dynamo and the leads, or whatever resistance was connected between the terminals F and E

$$= \frac{A}{B} \times R$$

Suppose there were 22 ohms unplugged in R when we obtained a balance, then as A = 10 ohms and B = 100 ohms, $\frac{A}{B} \times R = \frac{10}{100} \times 22 = 2{\cdot}2$ ohms, which is the resistance of the dynamo + the lead wires connecting F and E with T and T_1.

Disconnect the leads from T and T_1, and connect their ends together; now measure the resistance as before, and when a balance is obtained suppose R = 2 ohms, then

$$\frac{A}{B} \times R = \frac{10}{100} \times 2 = \quad {\cdot}2$$

Therefore the resistance of the dynamo = 2 ohms. When accuracy is required, the bridge should be "balanced" before use. That is, the terminals E and F are joined by a piece of thick copper strip or other conductor of practically no resistance, equal resistances are unplugged in A and B, and all resistance plugged in R. Then, since R = 0 and x, or the resistance between E and F = 0, when the keys are depressed there should be no deflection. If there should be any, look to all plugs and binding screws until the bad contact is found.

When putting in the plugs in order to obtain good contact the plug should be gently turned in the hole with a slight pressure until felt to "bite." It is, however, a very bad practice to force the plugs in, as it results in the breaking of the ebonite heads.

(TO BE CONTINUED.)

OLD CABLE STORIES RETOLD.—IV.

BY F. C. WEBB.

THE ATLANTIC EXPEDITION OF 1857.

On June the 5th, 1857, H.M.S. "Agamemnon," a 91-gun screw line of battle ship, arrived off Messrs. Glass and Elliot's works, Morden Wharf, Greenwich, to ship one half of the first Atlantic cable, a work which at that time was looked forward to with intense interest by the general public, as well as by the engineering profession.

The cable was by that time nearly all manufactured, one half (1,250 miles deep sea and 15 miles shore end) having been made by Messrs. Glass and Elliot, and the other half by Messrs. R. S. Newall, at temporary works in some warehouses at Birkenhead. The American Government had sent over their crack frigate the "Niagara," to carry half the cable, and that ship arrived at Gravesend in May, and on the 16th was visited by Messrs. C. Bright, Canning, and Woodhouse, and myself (engineers to the Atlantic Company), Messrs. Whitehouse (the electrician to the company), Statham (the manager of the Gutta Percha Company's works), and R. Glass. We found the ship greatly cut up by engines, decks, and bulkheads, and no holds to speak of. It was evident we must coil between decks, but then the finely-decorated ward room, of which the ship's officers were very proud, would have to be cut into. The captain and officers wanted us to coil the cable on the main deck in a kind of horseshoe form down two sides of the engine room hatch, and it was not until actual experiments were tried that they were convinced of the impracticability of this plan, and gave full permission to have their bulkheads cut away in all directions, and eventually the coils in her were as follow:—

In hold, forward of engines	352	miles	D.S.
On lower deck, exactly above this..............	182	„	D.S.
On main deck, exactly above this	294	„	D.S.
On main deck, between main and mizen masts	297	„	D.S.
On upper deck, above the last	130	„	D.S.
	1,255		
On upper deck, forward of foremast	10	„	S.E.
Total	1,265	miles.	

All these coils were in circular wooden structures, and had Newall's cones and rings fitted under Mr. Woodhouse's directions, who had before served on expeditions with Mr. Newall.

In the "Agamemnon" one large wooden tank of a peculiar shape was made in the hold, forward of the mainmast. It was nearly circular at its top and elliptical at its base. The cone had to be of a still more peculiar shape, for, to take the same number of thickness of cable in every direction at any flake between cone and sides of tank, it was made elliptical at bottom and nearly circular at top, and the top had to be less in diameter than the minor axis of the ellipse. A longitudinal section of it was like an exaggerated dumpy Eddystone Lighthouse, and a cross section was nearly like an ordinary cone. This was very cleverly worked out by Mr. (now Sir Samuel) Canning and Mr. Clifford. In this tank the whole of the 1,250 miles of deep sea cable was coiled, and 15 miles of shore-end was coiled on the orlop deck just forward of the main coil, thus leaving her lower main and upper decks quite clear of cable.

The paying-out gear in both ships consisted of four grooved wheels, on horizontal shafts, placed in series one behind the other, the two middle ones being a little higher than the others. These wheels overhung the frame. On each shaft was a spur wheel. These were geared in pairs, and between the two pairs was a pinion gearing into one wheel of each pair, and on the shaft of this pinion was a Prony brake and dynamometer. The cable fed on to top of No. 2 wheel, went three-quarters round and on to top of No. 1, then coming off bottom of No. 1, went straight to bottom of No. 4, off top of No. 4 to bottom of No. 3, then three-quarters round and off altogether at top of No. 3 to the stern sheave. But I am not going to discuss the machinery. A full drawing of this paying-out gear is given in my paper read at the Institution of Civil Engineers in February, 1858, and its merits and faults are there discussed. Coiling on board the "Agamemnon" began on June 16th. On the 28th (a Monday) it was found that the top flake of the coil in the yard, which had been standing all Sunday, showed signs of the gutta percha being melted. It was visible in little pimples (the size of a pea) outside the wires. The cable was cut 30 miles down, and tested by Mr. Whitehouse, and the portion below the cut passed. On the 16th of July places were found where the copper was quite through the gutta percha, and these were cut out.

The "Niagara" took her cable on board in the Mersey, as she could not enter the Birkenhead Dock, where Messrs. Newall and Co. were making the half of the cable that she was to carry. It was brought out in a small sailing ship. On the 20th of July a dinner was given at the Adelphi Hotel, Liverpool, to the officers of the United States frigates, "Niagara" and "Susquehana."

The "Agamemnon" was officered in a curious way, four masters—that is, what are termed staff commanders now—were appointed, one to do duty as captain, one as master, and the other two as lieutenants.

On July 24 we started in the "Agamemnon" from Greenwich. It was a very high tide, and as we passed Blackwall we seemed from the poop of the ship to tower up above the place, and had a bird's-eye view of the crowd on the wharf, that cheered us lustily. All the way down to Gravesend all passing ships cheered us. Now telegraph steamers are so common that notice is scarcely taken of them—at any rate, in the Thames. When we arrived off Gravesend it was strong ebb, and as the anchor was let go without first bringing the ship round head

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to tide, she swung round with such a spin that it nearly took us off our legs on the poop. I had given up my poop cabin to some ladies—relations of Mr. Nodall, R.N., who commanded the ship—and took one of a row of temporary cabins erected on the main deck. The next morning, just at dawn, the ship was getting her anchor, and I was suddenly awoke by a tremendous noise, with cries of "Lie down, men, lie down," and then a crash against the door of my cabin. I got up, and with some difficulty got out of my cabin, as one of the large capstan bars had been hurled against it. The ship had been steamed ahead before the anchor was off the ground and the cable having "taken charge of the capstan," the capstan was dragged round reverse way at a fearful velocity, knocking all the men over. The swiftsure then broke, and all the capstan bars flew out and came crashing amongst the men, who were lying about in every direction stunned. Three had broken legs, and seventeen others had to be laid up in the sick ward, but there were many more that were merely stunned. It looked just as if a shell had burst. We sent the three serious cases back by a tug to Woolwich. We anchored in Sea Reach for this, and got into Sheerness at 4 p.m. We left Sheerness on 27th for Cove. When past Dover we tried the machinery by paying out a bit of cable and heaving it in again. The paying-out gear was made to haul in with. Again on the 28th we tried some experiments, and I have a note that slack accumulated between the two end sheaves of paying-out gear. On the 29th we paid out a piece of cable rove through a rough-made machine which Professor Thomson (now Sir William) proposed for catching the cable if it broke. We cut the cable, but the end flew through without being caught. I have a note, too, that the brakes put a great deal too much strain on even when they were "hard off"—that is, when entirely released. On the 29th we came into Cove, and found the "Niagara," the "Susquehana," and H.M.S. "Leopard" all there. The "Susquehana" played "God save the Queen" as we passed her. Crowds of people came on board both cable ships. On the 31st I left with Mr. Cyrus Field and the Knight of Kerry for Valentia to choose a landing place for the cable. On the 1st August Mr. Field and I selected a place, and a tent was rigged up. Batteries and clerks arrived in H.M.S. "Cyclops" and the steam tug "Advice." On the 3rd the Lord-Lieutenant arrived at Valentia, and the next day a grand *déjeuner* was given in his honour by the Knight of Kerry. The other ships arrived the same day, and on the 5th we landed the end of the cable from the "Niagara." For this we used the paddlebox boats of the paddle frigates, and also the "Willing Mind" tug. When the end was ashore there were prayers, and then a speech from the Lord-Lieutenant.

The "Agamemnon" had remained outside cruising about in the bay, and I went off at 10 p.m. to her in a tug with several clerks and luggage. She was rolling heavily, although it was fine weather, but a swell on. She lowered a cutter and took me on board, but would not take the unfortunate clerks. When I got alongside it was not an easy matter to get up her side, as one minute the side ropes were scarcely within reach, and the next minute her lower deck ports were in the water. I managed a grasp at the side ropes, and the next second the boat was thirty or forty feet below me. When I got on deck I found the commander, Mr. Nodall, in a towering rage at having to lower a cutter at that time of night, when the ship was rolling so heavily.

"Here we have been," he said, "rolling about to that extent, sir, that we have had to set up the rigging afresh twice, and then you come off at this time of night with a lot of clerks and luggage." I said I could not help it as it was Mr. Bright's orders. "It's my opinion, sir," he replied, "that Mr. Bright does not know whether he is standing on his head or his heels, sir." This was scarcely a polite remark, so I went below to the ward room, and had some supper. I was now on board the "Agamemnon," and all the three other engineers on board the "Niagara," it having been arranged that Mr. Canning, who was appointed at first to the "Agamemnon," should go with the "Niagara," so as to make three engineers in the "Niagara" during the time of her paying out her cable, leaving me in charge in the "Agamemnon." I can only relate, therefore, what I saw from my own ship, and indeed these articles are not intended as complete histories, but only one person's experience.

On the 6th the "Niagara" started paying out, and was soon seen to turn back, and then forward again, and then back into harbour; then out again, apparently dredging, and then in again. On the 7th we sent a boat ashore with letters; boat came back, and we learnt that in paying out "Niagara" had got shore end of cable foul round axle of break, and had broken it. Had now under run in paddle box boat to a mile out, and then cable was cut, and shore end handed to the "Leopard," and end from "Niagara" passed also to "Leopard," and splice made in "Leopard." She started again at about 5 p.m., and at night we saw her stationary for some time. On the 8th, at 2 a.m., "Niagara" was about two miles from land; at 8 a.m. the whole fleet, consisting of "Agamemnon," "Niagara," "Leopard," "Susquehana," and "Cyclops," twenty-four miles from land; at noon thirty-seven miles paid out. On the 9th, at 8 a.m., "Niagara" signalled "coil on quarter deck out." At noon we were ninety-eight miles from land, and "Niagara" signalled ninety-nine miles out. I have a note saying, according to agreement, this would be in last twenty-four hours. At night "Niagara" was going very fast. On 10th at noon we had run 112 miles since noon the day before, and "Niagara" had paid out 111 miles. Probably this discrepancy is due to errors of longitude. At 5 p.m. "Niagara" suddenly backed, then we saw a large bight go over, after which "Niagara" signalled "all right."

The next morning my servant, who had been with me in the old "Monarch," came to me with the awful words, "Cable parted, sir!" and sure enough when I looked out of my port I missed the familiar thin line that used to be streaming away over the stern of the "Niagara."

We then closed with the "Niagara" to try some experiments. We passed end of cable to "Niagara" and broke cable. Passed it afresh, got out five miles, and then broke it; strain by the dynamometer, about two tons. "Niagara" tried to haul in her five miles from stern and broke it also. Mr. Canning now came back to the "Agamemnon," and all the fleet started, the "Agamemnon" and "Niagara" for Plymouth, where we arrived much disappointed on the 14th. Thus ended the first Atlantic cable expedition of 1857.

THE HEALTH EXHIBITION.—IV.

This introductory or explanatory matter is almost at an end, and then the various exhibits will be described. The methods of winding the field-magnets have been mentioned, but a greater diversity will be noticed in the mechanical construction of the armature. In principle all armatures are alike, and consist of an arrangement by means of which a conductor is carried into and out of the magnetic field, due to the excitation of the field-magnets. If we like we can represent the strength of a magnetic field by the number of lines drawn in a given space. Suppose, for example, in Fig. 2, we draw ten lines across the space between the pole pieces C D, that might be taken to represent a magnetic field of strength x; while a field of strength $2x$ would be represented by twenty lines across the same space, a strength of $3x$ by thirty lines, and so on. It is customary very often to imagine a magnetic field made up of forces acting along certain lines or directions, and to call these "lines of force." The greater the number of lines of force in a given space the greater the strength of the field at that point. It has been the aim of designers of dynamos to concentrate the magnetic field so that the conductor of the armature may pass from the position of no field to the position of greatest magnetic strength with the smallest possible change of space. If we use an instrument to indicate the direction of a current, the

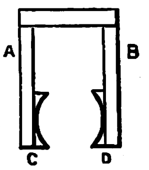

Fig. 2. Field Magnets of Dynamos.

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needle or pointer of the instrument swings in one direction when the conductor enters the magnetic field, and in the opposite direction when the conductor leaves the field. Hence there seems to be phenomena of an opposite character taking place when the conductor enters and leaves the field. If the current in the one case is known as + or positive current, in the other case it is called − or negative current, and a machine which first sends a + current through the lamp and then a − current is, as we have previously said, called an alternate current machine. The alternate current is used for all lamps of the Jablochkoff type, and frequently with incandescent lamps. In the ordinary arc lamps, with the carbons in the same vertical or horizontal line, the alternate current has to be changed into a continuous current. It is easy to see that a push and a pull alternately may move a block of stone or a log of wood in one continuous direction. We have only to make the push at one end and the pull at the other to attain our object. In order to change an alternate current machine into a continuous current machine, it is necessary to use a piece of mechanism called a commutator (Fig. 8). A simple form of commutator is thus made:—Take a cylinder of insulating material, shown in section by A, two strips of conducting material, such as copper, fixed to A, as shown at C C′, two springs S S′, which press either on C C′ or on the insulator A; the springs are connected to the terminals T T′. The wire through which the current is to go continuously is shown by *x*.

The wire in which the current is generated is shown by *y*. Let the direction of current required be from left to right. Then when the current in *y* is generated by rotating the arma-

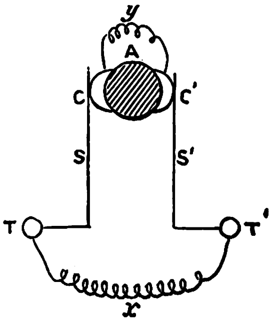

FIG. 8.—Elementary Commutator.

ture, the current passes as required with the apparatus as shown. If the current generated is in the opposite direction, then the spring S′ must be brought into contact with C and S with C′ in order that the current through *x* may be as required. All continuous current machines have some arrangement of this kind, and are therefore not so simple as alternate current machines. The reason why alternate currents are used with such candles as those of Jablochkoff and Wilde is that the carbon connected with the + terminal wears away twice as fast as that connected with the − terminal.

Thus, using two parallel or almost parallel carbons and alternate currents, the carbons consume at the same rate. It is this greater consumption of one carbon over that of the other that constitutes one of the difficulties of making a really perfect arc lamp. The one carbon, it will be seen, must be fed at twice the rate of the other. One word to visitors watching arc lamps may be useful, viz., to form no opinion as to the merits of one arc lamp over and above that of another unless the mechanism of the lamp is thoroughly investigated. The burning of a lamp may be an excellent test, it may, however, mislead. Frequently a good lamp burns badly, not from any fault except that of bad carbons. The carbons consumed nowadays are a wonderful improvement upon those used ten years back, but there is still much to be done before a perfect carbon is produced. With this preliminary information we may proceed to investigate the individual exhibits, without showing too much ignorance or being unable to follow the statements made.

(TO BE CONTINUED.)

ON THE MOST ECONOMICAL SIZE OF ELECTRICAL CONDUCTORS.

By W. L. HOOPER, Physical Laboratory, Tuft's College.

The problem of determining the most economical size of a conductor designed to transmit electrical energy for lighting, or as a source of power, is one of great importance and not difficult of solution.

Let E represent the difference of potential between the terminals of the main conductor at the dynamo, R the resistance of the conductor, *r* the combined resistance of the lamps, and C the total current, then by Ohm's law

$$E = C\,(R + r).$$

If P represent the energy of the current measured in horse-power, then

$$P = \frac{C\,E}{745} = \frac{C^2\,(R + r)}{745}.$$

The resistance is here composed of two parts; and since the heating effect of the current, or the loss of electrical energy in various parts of the circuit, varies directly with the resistance, the horse-power wasted upon the conductor is evidently expressed by the equation

$$P = \frac{C^2\,R}{745} \quad . \; . \; . \; . \; . \; . \; . \; . \quad (1).$$

Let *p* be the cost of an electrical horse-power transmitted to the conductor for one hour, and *n* the number of hours in a year that the current is used; then the cost of the current wasted in the conductors during the year will be

$$\text{Loss per year} = p\,n\,P.$$

Substituting value of P in (1),

$$\text{Loss per year} = \frac{p\,n\,C^2\,R}{745} \quad . \; . \; . \; . \quad (2).$$

Let R^{sp} be the specific resistance (the resistance of unit length of unit cross-section) of the material composing the conductor, *l* its length, and *l* its diameter, if round. Then the area of cross-section of the conductor will be expressed by

$$\square = \Pi \left(\frac{d}{2}\right)^2 = \frac{\Pi\,d^2}{4}.$$

The total resistance of the conductor will be

$$R = \frac{R^{sp}\,l}{\frac{\Pi\,d^2}{4}} = \frac{4\,l\,R^{sp}}{\Pi\,d^2} \quad . \; . \; . \; . \; . \; . \quad (3).$$

Substituting this value in (2) we have

$$\text{Loss per year} = \frac{p\,n\,C^2\,4\,l\,R^{sp}}{745\,\Pi\,d^2} \quad . \; . \; . \quad (4).$$

Let W represent the weight of unit length of unit cross-section of the conductor, then the

$$\text{Weight of conductor} = \frac{W\,l\,\Pi\,d^2}{4} \quad . \; . \; . \quad (5).$$

If the cost of unit weight *in situ* be *q*, then the

$$\text{Cost of conductor} = q\,\frac{W\,l\,\Pi\,d^2}{4} \quad . \; . \quad (6).$$

Let *i* be the current rate of interest, then

$$\text{Interest on cost of conductor} = \frac{i\,q\,W\,l\,\Pi\,d^2}{4} \quad . \; . \quad (7).$$

Now, the cost of the conductor, and consequently the interest on that amount, may be supposed to vary directly with its area of cross-section; but the resistance of the conductor, and consequently the waste of energy in it, will vary inversely with its cross-section. Hence the interest on the cost of conductor and the cost of the current wasted in a year will vary inversely with each other. Now, the sum of two quantities that vary inversely is a minimum when the two quantities are equal. The most economical size will

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therefore be that with which *the cost of current wasted in a year will equal the interest on capital invested in the conductor.* Hence

$$\frac{4\,p\,n\,C^2\,l\,R^{sp}}{745\,\Pi\,d^2} = \frac{i\,q\,W\,l\,\Pi\,d^2}{4} \quad . \quad . \quad . \quad . \quad (8).$$

$$d^4 = \frac{16\,p\,n\,C^2\,R^{sp}}{745\,\Pi^2\,i\,q\,W} \quad . \quad . \quad . \quad . \quad . \quad . \quad (9).$$

It will be noticed that l cancels out of equation (8), therefore the size of conductor is independent of its length.

EXAMPLE.

Let p		$= \$\cdot03$
n	$= 365 \times 6$	$= 2190$ hours
C		$= 1000$ amperes
R^{sp} inch, copper pure, at 0° C.		$= \cdot00000064645$ ohms
i		$=$ 8%
q per lb., *in situ*		$=$ \$·30
W cubic inch		·32523lbs.

Log. 16	$= 1\cdot204120$	Log 745	$= 2\cdot872156$
„ ·03	$= \bar{2}\cdot477121$	„ Π^2	$= 0\cdot994302$
„ 2190	$= 3\cdot340444$	„ ·08	$\bar{2}\cdot903090$
„ 1000000	$= 6\cdot$	„ ·30	$\bar{1}\cdot477121$
„ ·00000064645	$= \bar{7}\cdot810538$	„ ·32523	$\bar{1}\cdot512192$
	2·831223		1·758861
	1·758861		
	4)1·072362		
Log d	$=$ ·268090		

d = 1·8539in.

From equation (9) it appears that the area of cross-section varies with the current, hence a copper conductor that carries 10 amperes under the conditions in the above example should have a diameter of

$$\frac{1\cdot8539}{\sqrt{\frac{1000}{10}}} = \cdot18539\text{in.}$$ No. 5 gauge would answer.

It is important now to determine the heat generated in the conductor by the current. The heat in water gramme centigrade degrees generated by any current in t seconds is expressed by the equation

$$H = \cdot24\,C^2\,R\,t \quad . \quad . \quad . \quad . \quad . \quad (10).$$

The ratio between the gramme centigrade and pound F. degree is $\frac{9}{5 \times 453\cdot54}$, which multiplied by ·24 gives ·00095251.

Hence the heat in pound F. units will be

$$H = \cdot00095251\,C^2\,R\,t \quad . \quad . \quad . \quad . \quad (11).$$

Substituting for R its value in (3)

$$H = \cdot00095251\,C^2\,t\,\frac{4\,l\,R^{sd}}{\Pi\,d^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12).$$

The temperature to which the conductor will be raised in any time, supposing no heat is radiated or conducted away, will be the quotient of the whole amount of heat divided by the weight of the conductor multiplied by the specific heat (H^{sp}) of the material composing it.

$$T = \frac{H}{\text{weight} \times H^{sp}}.$$

Substituting for weight its value in (5)

$$T = \frac{4\,H}{W\,l\,\Pi\,d^2\,H^{sp}} \quad . \quad . \quad . \quad . \quad . \quad (13).$$

Finally substituting for H its value in (12)

$$T = \cdot00095251 \times 16\,\frac{C^2\,t\,R^{sp}}{W\,\Pi^2\,d^4\,H^{sp}} \quad . \quad . \quad . \quad (14).$$

Since in the above equation C^2 and d^4 are the only variables, T is constant under the same conditions for wires of different sizes, each carrying its most economical current.

EXAMPLE.

The copper wire in the last example, current 1,000 amperes, t one hour or 3,600 seconds, H^{sp} of copper being ·09515.

Log ·00095251	$= \bar{4}\cdot978869$	Log ·32523	$= \bar{1}\cdot512192$
„ 16	$= 1\cdot204120$	„ Π^2	$= 0\cdot994302$
„ 1000000	6·	„ d^4	$= 1\cdot072362$
„ 3600	3·556303	„ ·09515	$= \bar{2}\cdot978409$
„ ·00000064645	$\bar{7}\cdot810538$		0·557265
	1·549830		
	·557265		
Log T. =	·992565		

T = 9°·8302 Fahrenheit.

In the above example it is assumed, as has been before stated, that no heat is lost by radiation or conduction. But it is evident that a conductor whose temperature rises only at the rate of 10° F. per hour would soon reach a point where the heat given off would equal that acquired; hence, it could never be many degrees hotter than surrounding objects, especially if Professor Forbes's suggestion of making the conductors flat was adopted. I have no data for computing what this final difference of temperature would be for a wire buried in the ground (the only way to dispose of conductors carrying large currents), and it would evidently vary in different localities, but it is safe to say that the difference would be so small that it would only be objectionable on account of slightly increasing the resistance of the conductor.—*New York Electrician.*

ANNUAL REPORT OF THE POSTMASTER-GENERAL.

We make the following extracts from the Postmaster-General's report for the year ended March 31 last:—The number of telegraph messages despatched in the year was 32,843,120, an increase of 640,055 over the previous year. The increase in that year over 1881-82 was 746,165. The number of messages despatched in London was 12,639,192, as compared with 12,374,707 in 1882-83, and of this number 1,772,125 were for delivery in London.

On the subject of sixpenny telegrams and telephonic communication, Mr. Fawcett remarks:—"Although the introduction of a reduced tariff for telegrams has been postponed till the 1st of August, 1885, considerable preparations have been made in anticipation of that event. Many new wires have been laid and main lines commenced. By Treasury minute of the 14th of June, 1883, a total sum of £500,000 was authorised to be expended in providing the necessary plant for the new tariff, and of this about £180,000 was spent between August and the 31st of March. By far the larger part of the telephonic communication of the country continues to be supplied by private companies who hold licences from the Post Office. Frequent representations have been made that if some of the conditions which have been inserted in these licences for the protection of the revenue could be relaxed, the public might enjoy greater facilities in reference to telephonic communication. As it would be very undesirable to impose any unnecessary restrictions upon the development of telephonic enterprise, I lately suggested to the telephone companies that they should meet, and if possible come to an understanding as to the changes which they consider necessary to be introduced in the existing licences in order that the public may enjoy the greatest possible facilities for telephonic communication that are compatible with the revenue being properly protected. Various proposals have been submitted to me which are now being carefully considered."

The balance-sheet shows that upon the entire business of the department there was in the twelve months a net revenue of £2,687,100, the expenditure being £7,208,953, and the receipts £9,896,053.

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THE ELECTRICIAN.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes ... 265
The Elements of Electric Light Engineering. By E. C. Rimington. Illustrated ... 270
Old Cable Stories Retold.—IV. By F. C. Webb ... 272
The Health Exhibition.—IV. Illustrated ... 273
On the most Economical Size of Electrical Conductors. By W. L. Hooper ... 274
Annual Report of the Postmaster-General ... 275
Electric Light for Outdoor Recreation ... 276
Correspondence ... 277 and 278
The Transformation of Electrical Energy. Illustrated ... 278
Dynamo-Electric Generators. (Continued.) Illustrated ... 280
Electric Lighting for War Purposes ... 282
A Miners' Safety Lamp ... 282
Legal ... 283
Companies' Meetings—
The Direct United States Cable Company ... 283
The Globe Telegraph and Trust Company ... 284
The Consolidated Telephone Construction and Maintenance Company ... 285
Cuba Submarine Telegraph Company ... 287
The Anglo-American Telegraph Company ... 287
Submarine Telegraph Company ... 287
Anglo-American Brush Electric Light Corporation ... 288
Companies' Share List ... 288

ELECTRIC LIGHT FOR OUTDOOR RECREATION.

One of the best, though probably unintentional, services rendered by the Health Exhibition to the cause of health has been the attention it has drawn to the possibilities of outdoor recreation for town populations after the toils of the daytime and its sunshine are over. An evening contemporary last week warmly endorsed and backed up the recommendations of Mrs. Ernest Hart a few weeks ago, when advocating the extension of popular ballad concerts for the people, and the cry has been promptly echoed in several other quarters since then. We make no apology, therefore, for dealing with the subject in these columns, although hardly anything can be added to the excellent article in the *St. James's Gazette* of yesterday week. We have never thought much of the several attempts made last year both in England and elsewhere to enlist the electric light into the services of football or cricket at night time. The light is ill adapted for such occasions considered from the player's point of view, and still worse from the spectator's. Games of that kind, moreover, although healthy, are recreative only in a secondary sense, and their healthfulness depends, or rather is greatly due to the daylight, fresh air, and sunshine in which they are played. Besides this, they are suburban or rural in their main features, and we are now dealing with a subject peculiarly urban, where, therefore, the advantages enjoyed or easily procured by residents in the country are altogether absent. What is wanted for the half-stifled toilers within the boundaries of our large towns and cities is some provision for affording fresh air combined with recreation after nightfall, both of which are beyond their reach in the daytime. We have plenty of open spaces; all that is needed is light to illuminate them, and this we are rejoiced to see is now acknowledged to have been found in the electric light.

To the singularly dry and genial weather which continued through the spring and ushered in the summer we owe, no doubt, a great deal of the success of the Healtheries; but the experience of the last two or three weeks, during which time St. Swithin has had sole charge of the elements, proves that outdoor recreation may be taken in spite of him. Several experiments have been successfully carried out in imitation of South Kensington, even the hazardous one of acting Shakespeare's plays in the open air. And if this can be done in the daytime it is no longer impossible to do it at night. The fact is we take our unsettled climate too much as a matter of course, yielding ourselves to its uncertainty, when in reality a little self confidence would very soon demonstrate that in the summer time at all events rainfall is seldom continuous, and often confined to small areas. It rained in torrents in some parts of London on "Demonstration Monday," but hardly a drop fell in Hyde Park, though Oxford-street was drenched. Politicians may opine that there was a special providence in this, but the same will hardly be said for South Kensington, where the outdoor bands have not been prevented playing more than two or three times during the whole season.

But what is needed, more even than confidence, is a place of recreation to go to, and suitable provision for it when we have got there. This is to be found in abundance in the grounds of the Health Exhibition, and novel as is the experiment it has attracted already more than a million of people, most of whom we may safely conjecture remain there long after the surrounding parks have been enveloped in darkness, and closed to all innocent enjoyment.

On this point we cannot do better than quote the words of Mrs. Hart, in the address before referred to:—"Well do I remember one sultry August evening, now three years ago, riding up to town from the country. The sun had set when we left Richmond, and it was quite dark as we reached London. I proposed we should take the road through the park, so that we might canter through the deserted 'Row;' but when I reached the park its black darkness was alarming, and I was afraid to venture out of the road. It was Sunday evening, and the streets were thronged with the dense moving crowd seeking some relief from hot rooms—the great park was silent and deserted, given over to deeds of darkness. All London, namely, the well-to-do, were away on the moors of Scotland, by the seaside, on the Alps; the greater London, that were left behind, had the streets in which to enjoy the summer evening. 'Some day,' I said to my husband, 'this park shall be lit by the electric light, and we shall have bands playing every night to the public; and the people shall rest instead of pacing the weary streets.'"

Precisely the same remarks, we need hardly say, are true of the other parks in the east, north, north-west, and south of

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London, and the remedy is or might be precisely the same. Most of us have noticed with surprise and regret that in the very localities where open spaces least abound, and where the only available spot for open air exercise and recreation would be most appreciated, that one spot is ruthlessly closed at sunset. There are some obvious social reasons for this, it is true; but they would have been overcome before now if we had been in earnest in securing the benefits of outdoor enjoyment after dark, even on a limited scale. Imperfect illumination has no doubt had something to do with the restrictions; but this necessity exists no longer, for the electric light will give as much and as beautiful light as can be wanted at a cost which under such conditions would be far cheaper than gas, besides being infinitely more tasteful and more wholesome. Mrs. Hart's suggestions have been received with such warmth by the public that most probably some steps will be taken to fulfil her predictions before another summer comes round. We hope and believe that promoters of electric lighting will heartily co-operate in a movement which besides profiting them would effect a reformation much needed in the social life of the people.

CORRESPONDENCE.

DYNAMOS v. PRIMARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Writing to you with reference to the comparative steadiness of the light of the lamps in the hall and in the reception rooms on the occasion of the recent *conversazione* at King's College, Mr. Albright, on behalf of the Edison and Swan United Electric Light Company, does not contest, but endeavours to account for the fact that the steadiness of the light which was supplied from my primary battery was "in marked superiority to that of his lamps" by explaining that his dynamo was worked with an inefficient gas engine. It may readily be granted that under Mr. Albright's personal superintendence the working of that gas engine would have been greatly improved, but I am under the impression that many of your readers must have experienced similar disappointments when using other gas engines. If such an expert as Mr. Gerald FitzGerald would kindly furnish you with his experience of the lighting of the School of Telegraphy in Prince's-street, Hanover-square, that point might be impartially determined.

I think it fair to add that I am as much a "believer in dynamos" as Mr. Albright himself, but with this distinction. Dynamos and batteries in electric lighting may be compared to the steam-horse and the four-footed animal. For 1,000 lights, or the transport of 1,000 passengers, give me the dynamo and the locomotive; for family, or domestic purposes, the primary battery and a pair of horses in my stable. Each invention has its appropriate place. Engines and dynamos in the outhouse or cellar are sometimes an intolerable nuisance, but a battery can be placed there without the slightest inconvenience.

Electric lighting can never become general until more attention is paid to the practical obstacles which have beset its path. Some of the "believers in dynamos" would now have the public wait for central stations to be everywhere established, forgetting that, for the supply of only one-quarter of the light now obtained from gas, London alone (as the late Sir William Siemens pointed out) would require 140 such stations, each with from ten to fifteen 500 horse-power engines, and innumerable noisy dynamos, erected at a cost of no less that fourteen millions sterling.

Householders who do not wish to wait "it may be for years, or it may be for ever," ask for an alternative, and if the Edison and Swan United Electric Light Company has found that they are not all satisfied with the expedient of a gas engine and dynamo in their own houses, surely no one, it seems to me, should be more interested than that company in the very practical improvements which have been established in primary batteries.—Yours, &c., O. C. D. Ross.

21, Austin Friars, E.C., July 28th, 1884.

SMALL GRAMME DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have made a Pacinotti armature of the cog pattern with 20 teeth in it, and wound it with 3lb. 18cc. wire, 20ft. in each coil, armature 5in. diameter 2in. wide $\frac{7}{8}$in. thick. And will any reader be good enough to give me sizes of arms of F.M., and a small sketch how to wind the F.M.s and connect up in parallel arc? I want it to light about six 10 candle-power Swan lamps. I have got 9lb. 16cc. wire for the field. Hoping you will find room for this.—Yours, &c., H. P.

ELECTRO-DYNAMICS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The object of the paper read before the Electrical Section of the Franklin Institute by Mr. John W. Nystrom, and recently reprinted in *The Electrician*, is said to be to show the confusion in which the subject of electro-dynamics is yet involved. This object is admirably attained and kept in view at every step, for there is hardly a formula or statement in the whole of the paper which is not faulty. How far the paper will clear up the subject in America I am not prepared to say, but the elucidation is not likely to be greatly appreciated in England.

To start with an early statement, "No formulas can express quantity of work without representing the three simple elements—*force*, *velocity*, and *time*; and as the time is wanting in Count du Moncel's formulas, they cannot express work." With generous assurance Mr. Nystrom immediately presents us with the product of force into linear space, as representing work, but hastens to add that linear space involves time, because it is the product of velocity into time. As if velocity were a simpler idea than space. What the author fails to appreciate is, not that the quantities occurring in dynamics and in electricity, considered as a branch of dynamics, can all be expressed in terms of three of them, for he himself tells us what he considers the three simple *elements*, viz., *force*, *velocity*, and *time*, but it is the much wider generalisation that we may choose as fundamental ideas *any three* of the ideas considered, and express all the others in terms of them, subject to the condition that no one of the ideas chosen involves merely the other two or one of them only.

Thus a system could not be supported only upon the three quantities, linear space, time, and velocity, because velocity can be formulated in terms of space and time only. Nor could a system be raised upon volume, area, and any other third, because area can be formulated in terms of volume. But subject to such restrictions, any three ideas may be considered fundamental. It is customary to take linear space, mass, and time as the basis of formulæ; but Mr. Nystrom is perfectly free to choose force, velocity, and time if he wishes to do so. They form a thoroughly sound basis, but having been chosen should then appear in the formulæ expressing the other ideas, unaccompanied by signs of any other ideas. But in Mr. Nystrom's new forms he constantly introduces the signs of power and work, besides those of velocity, force, and time, the fundamental ideas. Thus as simple formulæ the new forms break down in many cases. They might, however, be true, without being simple, but for the introduction into the fundamental considerations of vital errors. Mr. Nystrom has taken current to have a similar formula with velocity, and potential to have a similar formula with mechanical momentum-producing force.

Adopting his fundamental conceptions, the formula for current is $F^{\frac{1}{2}}$ where F is mechanical force, and potential is $v\ F^{\frac{1}{2}}$ where v is velocity, so that it would be hopeless to look for any truth in the new forms of Mr. Nystrom.

As to force, power, and work differing in the same way that length, surface, and volume do, that is a statement bearing no intelligible interpretation. I do not wish to defend the omission by Count du Moncel of his *time*, nor have I verified the

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statement that he has omitted it. If he did, it was probably in a passage in which he felt his meaning would not be mistaken. The historian of "Scientific Ideas" occasionally uses the word *pressure* when he means *force*, but no one on this side of the Atlantic would accuse him of mental confusion on the point.—Yours, &c., THOMAS H. BLAKESLEY.

THE TRANSFORMATION OF ELECTRICAL ENERGY.

M. Hospitalier, at a conference at the Conservatoire des Arts et Métiers last month, read a paper dealing with the elementary facts of this subject. The following is a brief extract of the paper, which, although containing nothing new, may serve as a reminder of the constant "changes" which really constitute the tools of the world.

The text of the lecturer was the text upon which modern science is founded, "The Conservation of Matter and the Conservation of Energy." Change is everywhere, but nothing is lost, nothing created. The study of this law embraces all physical and chemical science, but we do not occupy ourselves here with the phenomena attaching themselves to any form of energy except that known as "electrical energy." The characteristic quality of electricity is in its transmission to a distance by means of a metallic conductor, the action being known under the name of electric current. The phenomena is not local, as with heat, nor is it necessary to attain a right line as with light, but we are able to direct the current as we please to the most convenient point of usage. The electric current is obtained by various means, chemical, mechanical, and otherwise, from apparatus designated as generators. On the contrary, any apparatus by which electrical energy is transformed into another form of energy—in virtue of the principle of reversibility—is a "receiver." Such are electric machines known as "motors," electric lamps, &c., which transform the electrical energy into work or heat.

If, on the other hand, the electricity re-appears on leaving the apparatus, but with different qualities to those it possessed on entering, the latter is known as a transformer. It is this class of apparatus, that we are about to study. From an industrial point of view their utility is not *a priori* evident. A transformer, whatever it be, is a costly intermediary; all agents, however employed, cost more or less for the service they render, and do not give out the whole of the energy put into them. By using transformers, therefore, a charge is burdened with a loss which varies according to the circumstances and the actual return—that is, the relation of the energy utilised to the total energy expended is subject in their case to the above impost. But the nature of each application of electricity necessitates a certain kind of current, having special qualities, which must be obtained to get the best result. If the generator at hand does not produce the current required, the employment of electricity necessitates a transformer which shall give to the current the necessary properties, and this may in certain cases be very advantageous in spite of the losses entailed. The better to understand this, let us compare the current which flows in a conductor to water circulating in a pipe. In the two cases the characteristics of the flow are:—(1) The force which produces the displacement; (2) the volume of delivery per unit of time; (3) the resistance to the flow. Water is displaced by virtue of pressure, difference of level, or height of fall; we express it in metres. Electrical motion is due to electromotive force or difference of potential, and we measure it in volts. The delivery of water, or volume flowing per second, is measured in litres per second, and of electricity in amperes. The unit of resistance offered to the propagation of the electric current is expressed by an ohm, whilst for water it is calculated by a fraction of the height of fall. Supposing we have three water-wheels working with a delivery of 1 litre falling from a height of 1 metre, we can arrange them in two different ways for the same expenditure of work, (1) by putting them one under the other, so that the water which has done work on the upper wheel shall fall on to the second and then the third. The characteristics of the fall will be 1 litre delivery with 3 metres of fall, a high fall and small volume. 2. We can arrange them side by side, so that each wheel shall receive 1 litre of water under a fall of 1 metre; the delivery will be 3 litres under a fall of 1 metre, large volume and small fall. With electricity the arrangements can be varied in the same way. If the current traverses all the machines successively, they are said to be arranged in tension, or in series, require high pressures, plenty of volts and few amperes. If, on the other hand, the current is divided between the various receivers or transformers, they are said to be arranged in quantity or derivation; in this case we require a large volume, plenty of amperes and little pressure, that is, few volts. If the generator at disposal does not produce the currents required by the arrangement of the machines, we must, in order to utilise it, have recourse to a transformer which will allow of variations according to our requirements.

Classification of Transformers.—If the transformed current has to be used at once, under penalty of losing the benefit of the operation, and if its form only is modified, the transformer is said to be *instantaneous*. If, on the contrary, a certain interval of time, more or less long, and theoretically unlimited, must elapse between the production and the utilisation of the current, the transformer is called a *deferred* machine. In each of these cases the result can be obtained directly by the effects of electrical actions solely, and the transformation is therefore direct; at other times another form of energy, work, or chemical action intervenes, according to circumstances, and the transformation is indirect. The following table, drawn up by M. Hospitalier, shows the different scientific and industrial applications of the numerous transformations of electrical energy. It shows at once what we shall ascertain later on by several experiments, that electrical energy has but one nature, but that this energy appears to us, according to circumstances, with very varied qualities of volume or pressure.

INSTANTANEOUS TRANSFORMERS.

DIRECT. *Induction.*	Interrupted c. into alternate c.—The Ruhmkorff coil. Undulatory c. into undulatory c.—The telephone. Alternate c. into alternate c.—Jablochkoff, Fuller, Gaulard and Gibbs. Continuous c. into continuous or alternate c. by commutation.—(Cabanellas). Extra currents.
INDIRECT. *Auxiliary use of mechanical energy.*	Continuous c. into continuous c.—Cabanellas. Manufacture of ozone. Continuous c. into alternate c.—Feeding Jablochkoff candles. Alternate c. into continuous c.

DEFERRED TRANSFORMERS.

DIRECT. *Electrostatic actions.*	Leyden jar. Jars. Condensers. Planté's rheostatic machine. Transformation by coupling up { + amperes − volts / − amperes + volts.
INDIRECT *auxiliary use of chemical energy.*	Maintenance of continuous work.—Electric flywheel. Convenient separation of work and time of production and consumption. Variable natural forces. Weak forces. Deferred utilisation. Modification of the qualities of the current. Splitting up and distribution.

INSTANTANEOUS DIRECT TRANSFORMERS.

Interrupted Currents into Alternate Currents.—The best known example is that of Ruhmkorff's coil, so frequently used in scientific investigations and experiments, such as for the illumination of Geissler tubes, Crookes's experiments, and so on. In

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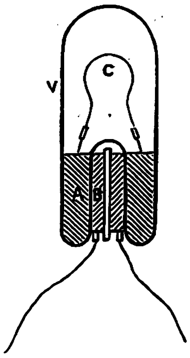
this apparatus, generated at intervals, currents of low E.M.F. and large quantity are transformed into currents of very high E.M.F. and of small quantity. The product volts × amperes is the same, in virtue of the principle of the conservation of work. The qualities of the ultimate current depend upon the proportional lengths of the primary and secondary coils. Thus, causing the current from six accumulators, with an E.M.F. of about 12 volts, to traverse a Ruhmkorff primary, we are able to render incandescent an Edison lamp requiring an E.M.F. of 100 volts by means of the secondary. The lecturer also explained how a double transformation could be obtained by using two Ruhmkorff coils. In either case the increase in volts is at the expense of amperes, or the increase in amperes at the expense of volts.

Undulatory Currents into Undulatory Currents.—This method has received numerous practical applications in telephony. For feeble resistances—that is to say, with short lines, the transmitter is placed in the direct circuit; but with greater resistances a relay is employed. From 1877 to the present time this method has been applied to from 5 to 600,000 apparatus.

Alternate Currents into Alternate Currents.—The aim of this transformation is to modify the qualities of the current, and assist the distribution. It has been studied by Spottiswoode, by M. Jablochkoff in 1877, by Fuller in 1879, and by Messrs. Gaulard and Gibbs in 1883. These latter gentlemen have employed the method in electric light operations. Another



Diehl's Lamp.

original application is in the incandescent lamp of Diehl (1882), in which he has avoided the most delicate of all the points in incandescent lamps—the differential expansion of glass and platinum. In this case the lamp is entirely enclosed in a glass case of special form, as shown by the figure. In the interior of the case V is a coil, A, the ends of which are connected to the carbon filament C. Another coil, B, wound round a soft iron core is placed as shown, and connected to the source of electricity. The filament C is rendered incandescent by the current induced in A.

Continuous Currents into Continuous or Alternate.—The transformation into continuous currents is by means of commutators conveniently arranged. If continuous currents are obtained they must be transformed into alternate for such purposes as the feeding of Jablochkoff candles. The *extra current* is an example of instantaneous transformation.

Indirect Instantaneous Transformers.—This class of transformers are used in mechanical operations. If we utilise the initial current provided by a battery or a dynamo with a motor, we obtain a certain quantity of mechanical energy, which can be employed in setting in motion a second machine, to produce continuous currents or alternate currents of high or low E.M.F., of large or small quantity, according to the use for which it is designed.

Deferred Transformation.

Direct.—The apparatus used is generally of that class used in electro-statics, and has been known for many years. Examples may be given in the case of Leyden jars, the ordinary condenser, and so on. The Leyden jar, for example, receives and preserves during a certain time the electricity furnished by a statical machine, and gives it up as required in a series of discharges or otherwise, or may be used to drive a statical machine and produce work. The use of a number of such discharges enables us to vary the conditions of discharge. One of the principal applications of condensers is in submarine telegraphy, for duplexing, in fact, the cables. The extensive application of this method is restricted.

Indirect Transformation.—Chemical action is the auxiliary used in this method of transformation. For example, a current is used to decompose certain chemical combinations. After a time more or less lengthy, under certain conditions the elements separated will recombine and furnish a quantity of energy sensibly equivalent to that which caused the decomposition. The secondary battery of M. Planté (1860), to which the name of accumulator has lately been given, is the type of this form of apparatus and has been employed in industrial work by Messrs. Faure, Sellon, Volckmar, and others. They are able to preserve their charge for several months without much loss by the employment of a series of accumulators and modifying the connections, and by the grouping in quantity or in series are able to obtain varying effects. Generally the grouping is not the same during a period of charge and discharge. Monsieur Planté has designed an apparatus to alter the system of grouping at these times, and M. Hospitalier has rendered it auto matic by a commutator worked by the armature of an electromagnet which effects the same operations. For electric lighting, for instance, the accumulators will be grouped automatically in quantity for charge and in series for discharge. These batteries of M. Planté permit us to make experiments in order to show the analogies which exist between statical and dynamical electricities. If with two Bunsen cells, giving a maximum of 3 volts, we charge 800 Planté couples, we can, connecting these in series, obtain an E.M.F. of about 16 volts, each couple giving about two volts. If with these currents transformed we charge 50 condensers made of plates of mica and foils, we may obtain a discharge of 32,000 volts and several millionths of an ampere, the effects of which will be comparable with those of a statical machine, or we can charge a Leyden jar, and repeat the experiments previously referred to. In order to give more interest to this part of the subject M. Hospitalier made an experiment, by means of which a piece of carbon of 9 mm. diameter was made red hot by means of the current from six Faure-Sellon-Volckmar accumulators. He expatiated upon the contrast between the results obtained before and after transformation. On the one hand we get a current of low electromotive force, and after transformation very high electromotive force. Accumulators are often employed for the regulation of continuous currents. With a variable source it suffices to put the accumulator in a branch circuit; in fact, the uses of accumulators are enormous. We may thus utilise natural forces, storing up the energy, and this application presents a grand field of research. The special properties of accumulators render them superior to direct transport, for which the initial force would not under certain conditions be sufficient, and under other conditions would be far too powerful. Storage facilitated, distribution diminishes the inconvenience of high potentials and counteracts any accidental stoppage of the original source of energy; it permits the employment of the varying forces of nature, such as wind and tides, &c., which may be utilised by having windmills or turbines, &c., likewise continuous force may be utilised to store up energy, which would be utterly inadequate to carry on the work during the short time. Thus Monsieur Menier lights his house with 150 incandescent lamps with a four horse-power gas engine, used to charge accumulators during the day. M Hospitalier then alluded to many other ways in which accumulators could be used with advantage. He concluded by a protest against the use of the terms "static" and "dynamic" electricity, which, he thought, would only confuse electrical students.

Erratum.—Electric Lighting at Terni.—By an unfortunate error the name of the town of *Terni* was misprinted *Turin* in our last week's issue. We shall be glad if our readers will kindly alter Turin to Terni wherever the name occurs on p. 250. Terni is a town some 30 or 40 miles from Rome.

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DYNAMO-ELECTRIC GENERATORS.

(CONTINUED FROM PAGE 260.)

DESCRIPTION OF DYNAMOS.

Gramme.

This is so well known that any lengthy description is not necessary; but, after noting the principle of its construction, I wish to consider the theory advanced by the late M. Antoine Breguet, and to advance a new one of my own.

In Figure 4 let R R be a soft ring enveloped by a continuous coil of insulated copper wire, *s s*. Suppose this ring mounted on an axis or spindle, and to be placed between the two poles of a permanent or electro-magnet, P P′. Opposite poles will be set up in the ring. Further, let the outer convolutions of the copper wire be denuded, and let two brushes, *c c*,′ rest in contact with the exposed parts. If the ring be rotated, currents will be induced in the upper and lower parts of the convolutions with reference to the central line A A, which will tend to flow in opposite directions. If the brushes were not in contact, such currents would not really be formed, for the two potentials set up being in opposition, and equal, and the circuit closed, precisely the same conditions would exist as if two equal batteries were joined, like poles to like—that is, in parallel circuit with the open terminal. If, however, the brushes are brought in contact with the denuded parts, and the circuit closed from one to the other, the two halves of the ring convolutions send a current through the external circuit, this current flowing in at one brush, *c*, and out of the other c^1—that is, one point is maintained at a high, and the other at a low potential. It is evident that by this arrangement low electromotive forces only would be

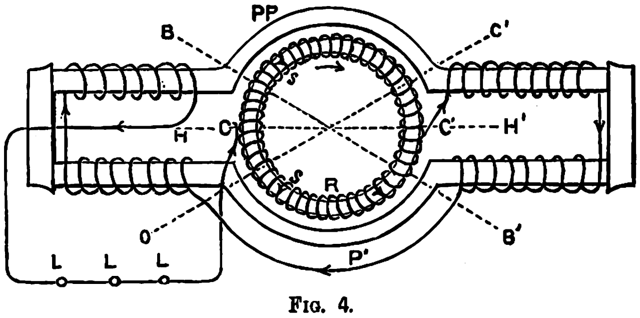

FIG. 4.

obtained, and the wires would soon be worn through. Then, too, if a solid iron ring were used, currents would be set up in the iron tending to heat it very much. To avoid these troubles M. Gramme replaced the iron ring by a hank of iron wire, which had first been drawn through a bituminous compound to cover it with an insulation, and instead of winding a continuous coil he replaced it by a series of coils—that is, the coils are much increased in number, crowded together, and theoretically every *n*th turn denuded. We have then a wire ring strung with a series of flat insulated coils. Then the bights of the coils, the connected ends, are joined to radial plates, and these plates in turn connected with wide strips of copper, there being as many strips as there are coils. The strips are built up into a circular range, which envelops the spindle, and is insulated from it.

The brushes are allowed to rest in contact with the range of copper strips, by means of which electrical contact is made with the external circuit. The contacts are at diametrically opposite points.

As the ring rotates the position of the coils with reference to the middle line and the field magnet poles is changed regularly and continuously, any particular coil passing successively into, through, and out of one field; into, through, and out of the opposite one, thus completing one revolution. There are therefore two changes in the direction of the current in a wire in one revolution. To put it in another way, the poles which are induced in the iron ring constantly shift around in the direction oppposite to the direction of the rotation, and since the shifting of the coils is by units and symmetrical the effort is constant and the current is perfectly continuous. To make a machine as effective as possible the wire of the armature is wound as closely as possible, and the field magnets have the poles extended over a full third or more of the ring, thus bringing a large number of turns, and a great length of wire into a strong magnetic field. On account of the difference of surfaces of the outside and inside of the ring, the inner turns of the wire are much crowded, and the free radiation of the heat developed in ring and coils is prevented. This interference is made even more objectionable by a wooden disc inside the ring.

In practice it is found that, if the brushes resting on the commutator are on the line which divides the field symmetrically, there is very considerable sparking, and to prevent this it is necessary to set the brushes ahead a distance depending upon the strength of field and current, the number of turns of wire, the mass of iron and the velocity of rotation to get the point of least sparking, the *neutral* point. This was formerly attributed to the fact that the iron in the ring did not gain or lose—that is, change its magnetic state instantly; but this explanation not proving satisfactory to account for certain peculiarities developed, M. Breguet conducted experiments, of which I will speak shortly, with a view of explaining not only the shifting of the commutator line, but the action of the iron ring. The Gramme machines seem to be made for certain currents, resistances, and velocities, and the brush holders are therefore fixed at a certain lead. In consequence of this practice, if run under any other conditions than the normal ones, there is much sparking, the commutator blocks and brushes are rapidly burned out, and this can only be partially reduced by changing

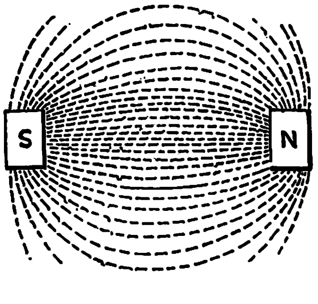

FIG. 5.

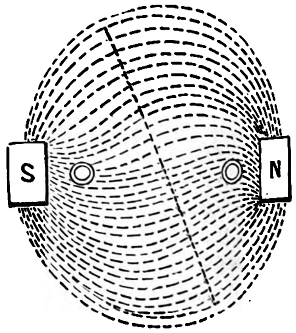

FIG. 6.

the length of a bushy brush—a, to my mind, very unscientific and impracticable way of working. The brushes ought to be compact and mounted on an arm which can be rotated around the spindle. This is a common practice on other machines, and works perfectly. The machine is a very effective one, converting a high percentage of the mechanical into electrical energy. It has, however, the faults already pointed out of an easily heated armature and of fixed brushes. There has been much dispute as to the true function played by the iron ring, it being formerly asserted that the action was the same as if the coils were fixed, and a circular magnet with permanent poles were made to rotate inside and through them.

Breguet's Theory.

With the view of ascertaining not only the truth about the Gramme machine, but about all dynamos, M. Antoine Breguet, a distinguished French physicist, recently deceased, conducted an elaborate series of experiments with various forms of electric machines, from those having but a single bend of wire, with ends dipping in mercury and rotating in front of permanent magnets, to the elaborate mechanical productions of commerce. With regard to the action of the Gramme ring, I will only briefly indicate some of his experimental results, and give the pith of his deductions. In Fig. 5, if N and S are the poles of a magnet, a field will be found between them of fairly regular character, but not very intense unless the poles are quite close. If a mass of iron of any kind be introduced into the field, the character of the field is changed, lines of force converge on the iron, because a line of force travelling through a mass of iron may be considered as shorter than if passing

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the same distance in air, and lines of force tend to shorten themselves. If, again, a conductor, with a current flowing through, be introduced into the field it will because of its own field, produce a distortion, the magnetic field being attracted or condensed on one side and repulsed on the other. Because of this attraction the conductor, if free to do so, will move, or if, instead of sending a current through it, it be moved through the field, the circuit being complete, a current will be formed in it. The principle of reversibility applies to all generators, which, if a current be passed through them, become motors. The strength of the current, if used as a generator, depends of course on the number of lines cut in a unit of time by a given conductor. If two conductors are used, as in Fig. 6, the current passing up one and down the other, there is a general letter S, or double curve, distortion, and if there are a number of con-

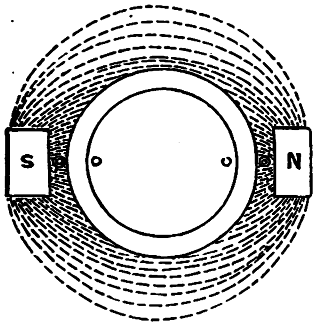

Fig. 7.

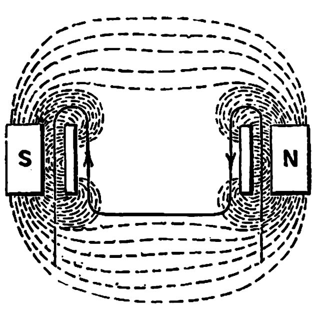

Fig. 8.

ductors this distortion is very marked. If we consider this field thus distorted, it is evident that a rotating conductor will be moving parallel to the lines of force when at a position not at right angles to field-magnet poles, but as shown by the oblique line, and, dealing with this conductor alone, if we are to obtain a continuous current, the connections must be changed when on this line. If, on the other hand, a four-part conductor is used a double distortion is effected, and the rotary effect is that due to the difference of the two, the balance being in favour of the outer coil, because of the longer radius and stronger field. If (Figs. 7 and 9) a ring is introduced in the field, there is a concentration of the lines of force all around, and if the field poles be extended, as in the

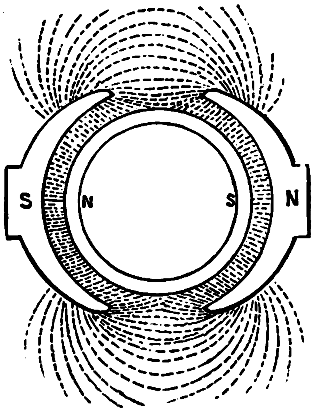

Fig. 9.

latter figure, a powerful field of wide extent is produced. Further, it is to be noticed that there are no lines of force extending across the interior of the ring, and that many lines are concentrated on the edge, and even turned inwards so as to cut the inner turns of wire in a favourable direction; in other words, the ring acts as a *screen* and a *concentrating mass* of iron (Figs. 8 and 9). If this ring be wound with wire, the inner turns (Fig. 8) not only do not act in a retrograde fashion, as in Fig. 3, p. 260, *ante*, but are even partially useful.

To sum up, M. Breguet held that the ring played the part of *concentrator* and of a *screen;* that the displacement of the commutator brushes is due to distortion of the field by the currents in the wires; that such distortion is lessened by the presence of the iron, because of the greater strength of field; that the displacement on account of the retardation of the iron is small—that is, retardation increases the lead if a generator, and lessens it if used as a motor; the machine being run in the same direction, the displacement when used as a generator and as a motor is in opposite directions because of the change of direction in the current, the field remaining of the same character; that the current is generated solely by the passage of the wire through a magnetic field across the lines of force.

Sprague's Theory.

While admitting the careful conduct of his experiment and the force of much of what he says, I cannot fully admit the truth of his deductions concerning the part played by the ring; in short, *it does not act simply as a soft iron ring at rest in a magnetic field.* Let me point out why.

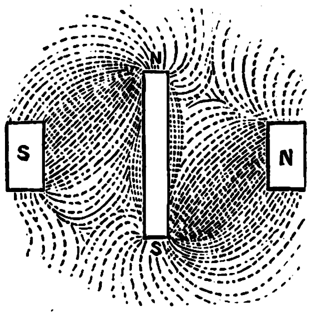

Fig. 10.

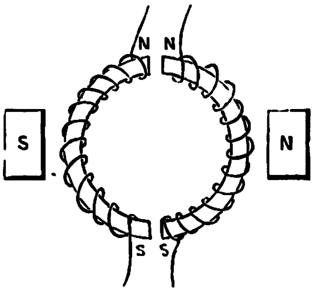

Fig. 11.

In Fig. 10, let a steel magnet, N′ S′, be placed in a magnetic field, just as the soft iron was above. Instead of concentrating the field all along its surface, the field will be much distorted, and in the manner shown, the greatest concentration being between unlike poles. If a semi-circular magnet is made use of, a similar distortion will be apparent, and if two magnets are used, their like poles being connected together, the distortion is still of the same character, and lines of force will be present inside the ring and extending from one of the poles in the ring to the others. There will be a tendency to induce poles at the neutral points of the ring, and if the main poles, N′ S′, are considered as induced by some means in a soft iron ring, which takes the place of the steel ring, then there will be two resultant poles formed at some points between the two single poles.

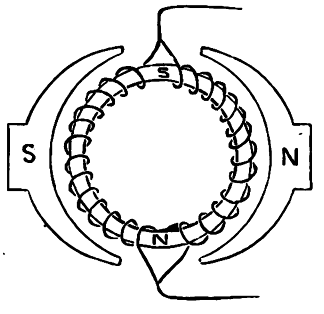

Fig. 12.

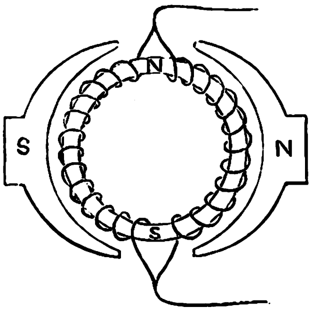

Fig. 13.

Instead of the steel ring we have been considering, let us put a soft iron ring in front of the poles, and induce compound poles at right angles to the induced poles by passing a current around the two halves of the ring in opposite directions, as in Figs. 11 and 12. We then have precisely the conditions we have just supposed, and a distortion which is *also* aided by the convolutions of the wire. If the current is reversed, the field poles remaining constant, the poles in the ring are reversed, as in Fig. 13, and in the two cases there will be a tendency to rotation, and in opposite directions, which tendency is *not alone* that of the mutual action of the current and the field, but *also* of the mutual action of the opposed poles. Now what occurs in practice? Since a current is generated in the coils by their motion in a magnetic field, these currents instantly *convert the ring from a simple soft iron screen into an active electro-magnet, whose poles are at right angles to the induced poles of the field,* and the strength of these poles depends upon the strength of the current flowing. The result is the formation of a compound

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magnet pole on each side of the ring, and a partial reinforcement and partial neutralisation of the magnetic action. If the generator is used as a *motor* to run in the *same direction* the current in the armature must be reversed, supposing the fields constant, and the distortion is also reversed.

The formation of a "transversal" magnet was pointed out by Pacinotti in the theory of his motor, and it, to my mind, plays an important part in the action of a generator. The "transversal" action and the Breguet theory are intimately associated, and are similar in their results.

(TO BE CONTINUED.)

ELECTRIC LIGHTING FOR WAR PURPOSES.

As we briefly mentioned in last week's "Notes," Aldershot was on Thursday week the scene of an experimental trial of Sautter, Lemonnier, and Co.'s portable electric light apparatus as an aid to the bearer parties whose duty it is to search for the wounded after a battle. The experiments were undertaken at the instigation of Dr. Baron Mundy, the chief of the Viennese Volunteer Society for Saving Life, and the funds were provided by the National Society for Aid to Sick and Wounded in War. The experiments were watched by a number of War Office officials and representatives of the Army Medical Department, Surgeon H. R. O. Cross being specially detailed to report on their success or otherwise. The apparatus was stationed on the brow of Cambridge Hill, and the light was projected on to the slopes of Redan Hill where a supposititious battle had been fought during the day, the result being that many wounded were left on the field. These were represented by soldiers specially told off for the purpose. Here we think that we cannot do better than quote the words of *The Times* reporter. "The demonstration commenced at 9:30 p.m., the night being very dark but starry, with occasional vivid lightning to the south. The bearer column marched out from the field hospital, which was supposed to be established about six miles from Redan Hill, where the imaginary action had just taken place. At a point assumed to be about two miles from Redan Hill, a dressing station was detached from the column. The column then proceeded to within about half a mile (assumed) of the battle-field, where the collecting station was formed with the ambulance waggons of the first line. From this station the bearers advanced to the field with litters to search for the wounded. Here a fine volume of light from the electric lamp very materially assisted them, not only in the search for the wounded, but in applying temporary dressings to the presumed wounds, the nature of which could have been easily ascertained had they existed. Beyond this the concentrated beam would have enabled higher surgical skill to have been brought to bear on the more serious and pressing cases if necessary. The work was very easily performed as an inspection of the numerous little groups dotted over the hill-side showed." Further on, he says:—"Considered as the first one of its kind at Aldershot, and subject only to a brief rehearsal on the previous evening, the demonstration may be considered a success. The light was well thrown on the battle-field, and at times on the collecting station. There were, however, three drawbacks, two of which were probably inevitable from want of time to test carefully the electric light after its transport across the Channel, and to arrange a brief but efficient code of signals. The consequences were that, in the first place, there were occasional short periods of darkness, owing apparently to the regulator of the lamp not acting properly, and, in the second, that the light was more than once directed on the collecting station when it should have been on the battle-field. The third drawback arose from the crowd of sightseers who had assembled from the town, and who at times greatly impeded the work of temporary dressing on the field and hindered the transport of the wounded. The first two of these drawbacks are remedial, while the third could not, of course, arise in practice. With these exceptions the work was very creditably performed. A further question, however, may arise with respect to the transportability of the electric light waggon. It is stated to weigh about three tons, and this is a heavy mass to move about over rough roads, roadless mountains, and sandy or soft soils. Then, again, comes the question of the detrimental action of transport under such conditions upon the comparatively delicate electrical machinery. It is true that the apparatus appears to be strongly constructed and well put together, and, moreover, it may be that the gross weight can be divided up for transport." The *Daily News* correspondent, who has had previous acquaintance with battle-fields, observes that the light was irregular, and points out that the hollows and reverse slopes of the hill, just the places where wounded men crawl when they can move, were left in profounder obscurity because of the intensity of the light falling on this side of them. He speaks, however, in very favourable terms of the experiment, and bestows praise on those who organised and carried it out. These, we may add, are Baron Mundy, Mr. John Furley, who assisted in bringing the apparatus from Paris; Messrs. Sautter, Lemonnier, and Co., its makers; the National Society, who provided the funds; and, lastly, Messrs. Woodhouse and Rawson, the well-known electrical engineers, who looked after and satisfactorily carried out the electrical arrangements. It will be interesting to read what Surgeon Cross has to say on the subject. We trust that there will be no great delay in the publication of his report.

A MINERS' SAFETY LAMP.

The adjudicators for the prize of £500 offered by Mr. Ellis Lever for a new safety lamp have now reported. They are Mr. Thomas Burt, M.P., nominated by the Central Board of the Miners' National Union; Professor Grylls Adams, by the Council of the Royal Society; Sir Frederick Abel, by the Council of the Society of Arts; and Professor Silvanus Thompson by Mr. Lever.

The following is the report:—"The adjudicators had to examine 108 lamps; of these four were electric lamps and 104 oil lamps, of which a few were designed to burn mineral oils. With respect to the electric lamps, there was not one which fulfiled, or approached fulfilment of, the conditions of the award. All the lamps which fulfilled the preliminary requirements were submitted to a series of experiments of progressively increasing severity. These experiments, based upon the experience gained by the Royal Commission, and by experiments instituted by other bodies in this country, were calculated to fulfil even exceptional conditions to which lamps may be exposed in actual practice. While there was a considerable number of lamps which behaved satisfactorily under the normal conditions existing in mine workings, the number was reduced to very few as the extreme tests were reached. Of these there is no one lamp that perfectly fulfils the whole of the conditions enumerated in No. 2, and the adjudicators are consequently unable to make the award to any one of the lamps submitted. Among the best there are two which the adjudicators regard as deserving of special mention—viz., the Marsaut lamp, with three gauzes, which most nearly fulfilled the conditions, and the lamp of Mr. William Morgan, of Pontypridd, South Wales, which presents several good features of marked originality."

Subjoined are the conditions of the prize, which were announced in March, 1883:—

1. The £500 to be invested in the names of three trustees, one of whom shall be Mr. Thomas Burt, M.P., the other two to be chosen by the Central Board of the Miners' National Union.
2. The lamp to be a perfectly self-contained electric lamp, or other lamp, which the working miners can conveniently carry from place to place in the mine, which will continue to give a useful amount of light for not less than 12 hours, and which will not cause an explosion of gas under any circumstances at all likely to represent conditions which may occur in actual practice.
3. The efficiency of the lamps put in for competition to be submitted to five gentlemen, composed as follows:—Three scientists to be named hereafter—one to be selected by Mr. Lever, one by the Council of the Royal Society, and one by the Council of the Society of Arts; one person representing the mining engineers, chosen by themselves, and one person representing the workmen, chosen by the Central Board of the Miners' National Union.
4. The adjudicators to meet in London after the allowed time for sending lamps for competition has elapsed.
5. The prize will not be awarded to any lamp now in use.
6. Not drawings or specifications, but lamps in a condition fit to be tested, must be sent for examination by the adjudicators.
7. The lamps must be sent to 2, Victoria-street, Westminster, London. No lamp to be sent in before 1st December, or none later than 31st December, 1883.
8. If a lamp meeting the requirements herein stated has not been invented, the £500 to revert back to Mr. Ellis Lever.

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The Brush Company v. United States Electric Lighting Company.

An American contemporary says:—"A decision by Judge Shipman was filed a few days ago in the suit of the Brush Company against the United States Electric Lighting Company, which manufactures and uses the Weston apparatus. The suit was upon the two principal patents granted to Charles F. Brush, one for metal-plated carbon points, and the other for an electric arc lamp, which, it was claimed, controlled the entire business of electric arc lighting. Before the argument the plaintiffs withdrew the carbon patent, and Judge Shipman now decides that the lamp patent is invalid and void, and dismisses the bill, with costs, as to both patents."

COMPANIES' MEETINGS & REPORTS.

The Direct United States Cable Company (Limited).

The fourteenth ordinary general meeting of this Company was held at the Cannon-street Hotel, Cannon-street, on Friday, July 25th, 1884, under the presidency of John Pender, Esq., M.P.

Mr. J. W. Fuller (the secretary and traffic manager) read the notice convening the meeting, and the report was taken as read.

The Chairman said: The revenue for the half year to 30th June, after deducting out payments, amounted to £68,573 8s. 11d., and the working and other expenses, including debenture interest and income tax, but exclusive of cost of repairs, absorbed £19,750 2s. 10d., leaving a balance of £48,823 6s. 1d. as the net profit of the half year, making with £3,524 8s. 6d. brought from the previous half year, a total of £52,347 14s. 7d., which has been appropriated as follows: Interim dividend of 5s. per share to 31st March, £15,177 10s.; proposed final dividend of 5s. per share to 30th June, £15,177 10s.; transferred to reserve fund, £19,030 15s. 11d.; final balance of liquidation expenses, £175 10s. 1d.; balance carried forward, £2,786 8s. 7d. This makes the total £52,347 14s. 7d. The revenue shows a decrease of about £2,000 as compared with the corresponding period of 1883. This, as you are aware, is more or less due to the extreme depression which prevails in commercial circles in America at the present time, and in fact in our own country as well. The working expenditure in London and at stations compares as follows with that in the same half of last year, viz.:—The salaries at stations show a reduction of £544, while those in London are £303 higher, the balance of saving on the salary items being thus £241. The items of office expenses and stationery in London, and of petty expenses, repairs, printing and stationery at the stations all show a reduction; but this is slightly counterbalanced by a temporary increase in the cost of maintenance and renewal of instruments, and in travelling expenses, incurred principally by transferring or sending out clerks to Company's stations. These two items are always more or less of a fluctuating nature. The reserve fund, after being charged with £5,127 18s. 9d. (the cost of repairing the short section of cable between Torbay and Rye Beach) and being credited with the interest on the investments and amount transferred from revenue account, shows a balance of £360,000—a net increase of £45,000 for the financial year. The reserve fund investments remain the same as in December last, the slight difference in amount being composed of additional calls on the West of India Portuguese Railway Stock. The uninvested reserve and other moneys remain on deposit at the Company's bankers, in view of the repayment shortly of the Six per Cent. Debenture Loan. The present market value of the Company's investments is about £11,000 more than the figure they stand at in the balance sheet. These are some of the details, which are more fully given than appear in the report, and I believe you will agree with me that upon the whole the report for the last six months may be considered satisfactory. As you are aware, both in America and at home there has been a very extraordinary commercial crisis, particularly in America. A great many men who two years ago, when I was in America, were millionaires are to-day almost penniless. With such changes as these of course telegraphy suffers. It is very different indeed when trade is in the other direction. Profits are made out of almost every transaction—those transactions beginning and very often ending with the telegraph, which, as you can well understand, creates considerable activity. I hope as one extreme begets another we may see a reaction in America, for no doubt when that takes place telegraphy will feel the effects. An important incident in the last six months has been the repairing of our short cable. The cost has been taken from the reserve fund, but we have notwithstanding placed a substantial amount to that fund, and it now stands at a figure with which we have every reason to be satisfied. I may mention that during the last few months I paid, with the traffic manager, a visit to our stations on this side of the water—at Chester, Liverpool, and Ballinskelligs in Ireland—and I am very pleased to say—it was my first visit to the stations—that I found everything in a most satisfactory state. The young men are all very well housed, and are living on the premises, and the business is conducted in a thoroughly satisfactory way. I spent one day there testing our cables. It is not a particularly lively place, because you are very much out of the world there. Well, I thought I might spend a couple of hours pleasantly by carrying on a conversation by cable with Dr. Green, the president of the Western Union Company of America. There was nothing doing on the line, but of course our young men were ready for any business that presented itself. I kept up a very pleasant talk for two hours with Dr. Green in New York, very much in the same way as if I had been carrying on a conversation with that gentleman in this room. It proved to me how thoroughly satisfactory our cable was, not only as to speed, but also as to accuracy; and when I came to look to the amount of matter that passed over the wires in those two hours, I was astounded. We talked about the crisis in America and its effect on telegraphy, and also about the future, and what would probably occur by and by when the new cables were opened, and the marvellous accuracy and quickness with which all this was conducted would have struck any stranger with surprise, as it indeed did me, though I am Chairman of the Company. But quick and rapid as the system seems to be now, such is the progress of electrical science that I have no doubt at all before very long we may find that the present speed is materially increased. I believe, at the present moment there are experiments going on which may lead to a most material increase in speed. When I last addressed you I spoke rather at length. I went into the history pretty much of this Company and the history of submarine telegraphy in the Atlantic generally, and I referred to the coming competition—that is, the competition which is about to take place with the Mackay and Bennett cables. Well, gentlemen, on this subject I have very little to say to-day. One of those cables has been laid. They expect to lay another, I believe, within two months; and I am told that until after the second cable is laid the competition is not likely to arise. All I can say is that when it does arise we shall be prepared to meet it in such a spirit as will protect your interests. I have no idea of throwing away money if we can save it, but our policy will be guided very much by the policy which the competing company may act upon. In regard to the competition, when it does arise there is one thing which I think I may safely say, and that is that we have got experience; we have also got in our combination eight cables, and whoever can do the work quickest and best is likely to get the greater share of the traffic. In commerce there is very little sentiment. Every man knows best what suits his own interest, and sentiment is a thing that he never pays for. He will employ those who do his work best, and I feel satisfied, knowing what we have to compete with, and knowing the experience of those who have to deal with the existing system, that if we do not get our full share, and probably more than our full share of the traffic, we should not be doing our duty. There is another point I may mention, and that is that the present cables are equal to a very much greater amount of traffic than we have got. Mr. Bennett has frequently stated that he is indifferent about outside traffic, as he can pretty well employ those cables for his own press purposes. That may be an advantage, and a very considerable advantage for us. There is very great competition among the press in America, and and they will not let Mr. Bennett have his columns filled with English news without doing the same. And I therefore look upon it in this light—that the newspapers are not likely to send their press messages by such a formidable opponent in the press as Mr. Bennett, of the *New York Herald* is. Therefore, I think Mr. Bennett's action in that respect will contribute very largely to the number of the press messages we are likely to receive. However, as I said before, a few months will tell more than any prophecy of mine will do. I may mention, however, that from what I learn Mr. Mackay is a man of very considerable business ability, and that he understands exactly what he is about. I am told that he has given one of his officials the grand title of Director-General, and has taken upon himself the more humble designation of manager of the company. I believe that in Mr. Mackay, while we shall have an active and energetic opponent, we shall have a man of business, who will meet us on fair ground, and that is the class of men I like to fight in a contest of this kind. There is another important point I wish to refer to, which I think met with the great approval of the shareholders at the last meeting, namely, that we are going to pay off our £100,000 of debentures, and take it from the reserve fund, still leaving a very handsome reserve. Instead of taking £100,000 out of the reserve fund, that being the amount that we have to pay off, I believe we shall only require to sell out something like £70,000 of the reserve fund, and that we shall be able to make up the balance of £30,000 out of our floating reserves. That is a point which I think upon the whole is very satisfactory. I think I have pretty well exhausted all the points to which it is desirable to draw your attention. I am reminded that by paying this £100,000 off it is a saving of £6,000 a year to us. Besides that it places us in a more sound financial position. As to our policy with respect to the future, as I stated, I shall be able to tell you more six months hence; but that policy will always be based upon strengthening as far as we can and maintaining as much as we possibly can the financial position of the Company. With these remarks I beg to move the following resolution:—"That the report of the directors, dated the 16th July, 1884, together with the statement of acounts to the 30th June, 1884, annexed thereto, be and the same are hereby adopted, and that a final dividend be now declared of 5s. per share, free of income-tax, making with the interim dividends already paid a total dividend of 5 per cent. for the year ending 30th June, 1884."

Mr. Wm. Ford: I beg to second the resolution.

The Chairman: Before I put that resolution, if any gentleman at our meeting desires to put any question to me on the report or on the remarks which I have made, I shall only be too happy to answer him to the best of my ability.

Mr. Jackson: If I might occupy your time I should like to ask a question. But before doing so I should like to express as an original shareholder my great satisfaction at the present report. For seven years we have received a steady 5 per cent. dividend, and have accumulated a very handsome reserve fund. I was very glad to hear from you that in your opinion it was not impolitic to reduce the renewal fund, and the saving of £6,000 a year, which is the amount which will accrue to the Company, is more than would cover the expenses of the half-year's payment to the Anglo Company. I think the shareholders of this Company ought to be eminently satisfied at the financial results of the working of this Company, for the parent Company—if so it may be called—is paying its

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shareholders, or rather it shows a bare 3 per cent. returned, and a very large proportion of its capital is deferred stock. That stock represents 30 per cent. of the total capital of the Company, and they have only paid ½ per cent. on that for the last two years. It must be eminently satisfactory to us, I think, to find that we, who are only an auxiliary as it were, should have received in the face of these facts such a handsome dividend for so long a time, and I think that the shareholders have you and the Board to thank very much for conducting their affairs with such highly satisfactory results. You have assured us that this reduction of the renewal fund is a perfectly safe course. I think that is a very important feature, because outside there is a very general opinion, and I believe a well justified opinion, that a renewal fund is the backbone of a deep sea telegraph company. There is one other question I wish to ask—Why should not the United Companies offer to carry deferred telegrams at a reduced price? I do not presume to do any more than offer a suggestion. I hope you will give us some reply, as your great experience would enable you to say if it were possible.

Mr. JOHN NEWTON: At the last meeting I raised the question of dividing our shares into £10 shares. I mentioned then that it was astonishing to me that our shares should stand no better than they do in comparison with those of every other telegraph company who are not doing better for their proprietors. I think if you made our £20 shares into £10, so that we could compare the price with others in the price list, we should see better how they stand in the comparison, just as we do in in the case of the Eastern and the Eastern Extension Companies. I also hold that one-tenth is better that one-fifth in the matter of these calculations. It strikes me the position of the Company is not fairly represented by the Stock Exchange prices. When you contemplate what it costs to lay a cable from England to America, to establish stations and get together a business, it seems marvellous that our property should stand at the price it does. I think the question of making our shares the same as all the others is well worthy of your consideration.

The CHAIRMAN: I have great pleasure in replying to any suggestion or remarks from Mr. Jackson or Mr. Newton. In the first place Mr. Jackson put the question, and I think put it very properly, do we in any way endanger the position of the Company by reducing our reserve fund by this £100,000? I do not think we do, and for this reason. As you are aware, although we are a single cable—and I do not think this is always considered—we have the guarantee of seven other cables for twelve months—that is, we could not lose much in our income for twelve months, and during that period we have time to make our arrangements for repairs. We are taking up cables now from the bottom of the Mediterranean and the Atlantic, and every year convinces me more that the life of a cable is likely to be a much more prolonged one than we thought a few years ago. As I said now, by paying off this £100,000, we only take £70,000 from the reserve fund, and we save £6,000 a year. Well, that in a few years makes up very soon a considerable amount with the extra value of our investments After taking away this amount from the reserve fund, it would still stand at over £300,000. That is a very handsome reserve. By this reduction of £100,000 we place ourselves altogether in a better position. If our cable broke, and we had £100,000 debentures out, we should have to pay, if we wanted more debentures, very much more interest than if we had no debentures at all. That is a very important point, and I am quite satisfied we shall strengthen our financial position by wiping off that £100,000. I think I have shown you that although we are a single cable we are uncommonly well backed, and that that backing is worth a considerable amount to the Anglo-American. When the bargain was made I think it was pretty well understood that we got a very fair share of the traffic at that particular time. Mr. Jackson has made a point which, I must say, has very often struck me—that is, that telegraphy has not made the leaps and bounds that it did in its early stages; but I must tell you that submarine telegraphy is at the cheapest an expensive luxury in business. It is rarely taken up in social life, and consequently upon the growth of trade in a great measure depends the growth of telegraphy. We are passing through very dull times, and times which I hope will not continue for ever. But there is this advantage that we have. If some people say trade is going to leave this country, it is going to other countries; and such is the ramification of the submarine telegraph system now, that if we lose at one point we shall gain at another, because, whatever is produced in a distant country is not kept for the consumption of its particular inhabitants, but is scattered all over the world, and it is through the submarine telegraph system that this scattering takes place. If we could enlist something in the way of social telegraphy, as Mr. Jackson has hinted, no doubt it would materially increase our traffic. But you must bear in mind this important point, that submarine telegraphy is not like land telegraphy. We can only carry a certain number of messages upon a submarine cable. When we get at that point, if the money we can make out of those messages does not pay us, then it becomes a loss. We cannot extend as we would upon a railway, where you can put down an extra rail. We can only run so many words in a minute, and if that number does not give us a return it is no use working at a loss. I may also say that we had tested the shilling rate and the sixpenny rate upon submarine cables, and it is a remarkable fact at the shilling rate we only got something after a year's trial like 30 per cent. increase in traffic. That 30 per cent. left a very serious loss indeed upon the working of the cable. If we were paying handsome dividends we might experiment a little, but as we are paying what I consider a very moderate dividend indeed, we must protect the shareholders first before we deal with the general public. With regard to Mr. Jackson's suggestion, however, I have some ideas in my head which I hope will be carried out by and by. But probably it would not be very safe to say very much about that at the present time. I do think, however, that we may make some attempt by and by to try and tap the social system. This is a point that will be fully considered, and if we can do it it will be done. I may add that probably, as competition goes on very actively, we may reduce our rates, but that is a prophecy which I do not say much about now. As to reducing the denomination of the shares, the Board have given that question their full consideration. It cuts both ways. It is true that our shares are now £20, and if we reduced them to £10 of course they would stand in the market a little above £5. That is a very great discrepancy, and it is not a position which our shares are at present entitled to occupy, because I consider the shares of this Company a really valuable and great property. But which would have the greatest effect on the investor? It is a question to me whether the shares are not better at the present moment to stand at £10 or £11 than at £5 or £6. I think the investor is a little more inclined to go in a little over par rather than a little under par. We have, however, considered this point, and I do not think at the present moment it would do the good that Mr. Newton believes it would do in the way of increasing the value of the shares. If we saw it in a light that it would benefit us in any way, by increasing the value of the property, we would do it. Although this is our present view of this question it is a matter which still admits of consideration, and we may possibly by and by change our opinion.

He then put the resolution in the usual manner, and declared it carried unanimously.

Continuing, the CHAIRMAN moved the re-election of Mr. Wm. Ford as a director.

Mr. E. M. UNDERDOWN seconded the motion, which was carried unanimously.

The CHAIRMAN next moved the re-election of Mr. C. J. Gunther to his seat at the Board.

Lord HAWKE seconded the motion, which was carried unanimously.

Mr. JACKSON proposed the re-election as auditors for the ensuing year of Messrs. John George Griffiths and John Sawyer. Those gentlemen, he observed, represent our interests, and I have much pleasure in proposing their re-election. I think the results of the working of the Company afford satisfactory evidence that their audit is a good one.

Mr. VARLEY seconded the motion, which was carried unanimously.

The CHAIRMAN having intimated that that closed the business of the meeting,

Mr. VARLEY said: I have great pleasure in proposing a vote of thanks to the Chairman and the Board for the very admirable manner in which they have conducted this Company's business. I also, like the Chairman, look on these shares as a very splendid investment at the price, and I only wish that some of the shareholders would do what a relative of mine has done—purchase some shares, borrowing the money at 3 per cent. to do it, and he has very nearly paid the loan out of the investment.

A SHAREHOLDER seconded the motion, which was carried unanimously.

The CHAIRMAN: I have very great pleasure in returning thanks for the compliment which you have paid us in thanking us for our good management of the Company. I have also to thank you, especially as Mr. Ford requests me to do so on his behalf and on behalf of Mr. Gunther, who is absent. As I have said, your Board's first consideration is the interest of the Company. We have known it in adversity, we have plucked it in some measure from the fire, and I think none of us, either on this side or that side of the table, have any reason to regret the action that was taken. The Company now holds a very good position. I believe it to be a very sound investment and, believing as I do that telegraphy must grow, I do not see why we should not grow with it.

The proceedings then terminated.

Globe Telegraph and Trust Company, Limited.

The eleventh ordinary general meeting of this Company was held on Tuesday July 29th, at the City Terminus Hotel, Cannon-street, under the presidency of John Pender, Esq., M.P.

The SECRETARY (Mr. Wm. Payton) read the notice convening the meeting, and the minutes of the last meeting. The report of the directors was taken as read.

The CHAIRMAN: Before I ask you to approve of the report, I shall give you a few particulars of the incidents of the last twelve months' working which do not appear in the report. As you observe, we pay this year the same dividend as last—namely, £4 15s. per cent. on the ordinary shares, which with £6 on the preference shares, is equal to a dividend on the combined stocks of £5 7s. 6d. per annum. As regards the revenue, you find that there is a falling off in the dividend of the Anglo-American Company—on their preferred stock—during our financial year of ½ per cent., which is equal to £1,546. This, however, they have made up by their last dividend. The Brazilian Submarine Company has also paid 1 per cent. less—6 per cent. as against 7 per cent. in the previous year. This has arisen from an unfortunate break they had, which represents a difference of £2,548 to this Company. The Indo-European Company also paid 1 per cent. less—8 per cent. as against 9 per cent.—representing £1,172, the higher dividend of the previous year being attributable to the interruption of other lines. Some other companies in which we have but a small interest also paid lesser dividends, making a difference of £5,500 in all. Against these items, however, may be placed what the Eastern Company have paid—½ per cent. more, or 7 per cent., as against 6½ per cent., equal to £7,895—and this has enabled our Company not only to maintain our position as compared with the previous year, but to carry forward a larger balance, as the accounts show—£2,088 this year against £1,375 last year. The items of expenditure on revenue account are a trifle less than last year. Our proprietary is increasing. We have now 7,000 shareholders, being 500 more than last time, and as you are aware, this entails, as we pay quarterly dividends, a considerable amount of outgoings for stamps, &c. The report explains that we have been able during the past financial year to free the Company from a liability on capital account in respect of the Eastern Extension Company's shares for which we stood as creditors to the extent of £130,130 in our last balance-sheet. We accepted an offer for the issue of an equal number of our own shares, preference and ordi-

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nary, in combination, and we have transferred 3,182 of the Extension Company's shares. This gives us now a clean position. In issuing our Globe shares we have to deal with them according to the market value, and while the preference shares are at a premium the ordinaries are at a discount, although at the present market price the ordinary shares pay 6⅝ per cent. The discount on the total issue has to be added to the cost of the shares. This transaction was a fortunate one for that company. The Company has now been in operation for eleven years, and at this first meeting of our second decade we take with advantage a retrospect of your position, and it will show, I think, that no class of shareholder who bought his interest in the Globe Company has, if he calculates interest and dividend, any cause to regret it. I have just referred to the time of the formation of the Company. When this Company was formed the Anglo-American Company was paying 8 per cent., and we took over their stock at 152. The difference in value is a very material and a very serious one to-day. The Atlantic seems to have been a very favourable channel for investing money, and even now we are likely to meet—that is, the telegraph companies—still further competition. How that may end it is very difficult to say. The public, no doubt, will derive a certain advantage for the moment, but whether they will derive it in the long run it is difficult to say. There is a steady progress in telegraphy, and that steady progress has perhaps more rapidly developed in the Atlantic, more particularly when trade is active on the other side of the Atlantic, and on this side it is marvellous the progress it makes. Meantime it is all depression, and those who are now coming into the contest will find that it is no light venture that they have entered upon. Those in possession are likely, from their great experience and the number of cables at their command, to do the work so much better than any new competitors, and I am quite certain that their proportion will always be the largest proportion as compared with their competitors. I may mention also that the French stock was taken at £36 10s. The change there is also very striking, but, at the same time, we have maintained our dividend very fairly to you, from the fact that the Eastern and the Eastern Extension shares, which were taken at share for share, also the German Union, are now paying advanced dividends—not only paying dividends, but the value of the stock is very largely improved. The Brazilian Submarine Company are now, we may say, in a very sound and safe position. Any company with duplicate cables is likely to keep up continuous earnings. I believe that the loss alone during the time the Brazilian Submarine Company's cable was broken down, and before they got duplicate cables established, amounted to over £30,000. That is a very large item out of the dividend for a year. That is now, I hope, at an end, because the Brazilian Submarine Company has duplicated its system, and in that Company we are large shareholders. I need say very little with regard to these American cables at the present time, but I may say, as to our Eastern system, that it seems to me that we may expect a fair progress there. We have always been ready not only to meet the requirements of the Government—I speak of the Eastern and the Eastern Extension Companies—but it has been done in a way to command the approval of the Government, and I think also the approval of the telegraphing public, and with rather an advantage than otherwise to the shareholders of those respective companies. As you know, we are entirely dependent on the good management of those submarine telegraph companies, but speaking from a thorough knowledge of them, I have no hesitation in saying that the Boards of those companies are quite alive to the changes that are taking place from time to time, and from their great experience and general knowledge know how to meet every difficulty. I think their prospects are such that, apart altogether from American competition, we shall be able to maintain a fair dividend arising out of those other companies. Now, gentlemen, with these remarks I beg to propose "That the report and accounts for the year ended 18th July, 1884, submitted to this meeting, be and they are hereby received and adopted, and that a dividend be now declared payable after this day of 3s. per share on the preference shares, making, with previous quarterly payments, a total dividend for the year of 6 per cent. on the preference shares, and 3s. 6d. per share on the ordinary shares, making, with previous distributions, a total payment for the same period of 4⅞ per cent."

Sir Daniel Gooch, Bart., M.P., seconded the motion, which was at once carried unanimously.

On the motion of the Chairman, seconded by Mr. H. D. Gooch, Mr. Wm. Ford was re-elected a director.

The Chairman next moved, and Sir James Anderson seconded, the re-election of Sir Daniel Gooch, Bart., M.P., to his seat at the Board, and the motion was carried unanimously.

On the motion of Mr. Burnham, seconded by Mr. John Newton, the auditors, Mr. John Griffiths, F.C.A. (Messrs. Deloitte, Dever, Griffiths and Co.), and Mr. W. Griffith, B.A., were re-appointed.

Mr. Heiron next proposed a vote of thanks to the chairman and directors.

Mr. W. Griffith, B.A., seconded the motion, observing that their position was all that they could desire. They had reason to believe that everything was going on as it ought to do, and he found that the public at large were approving of the Company, and that it was rising in favour.

The motion was carried unanimously.

The Chairman: I beg to thank you on behalf of my colleagues sitting at this Board. I have limited my remarks to-day, because within the last few days important meetings have been held of some of our submarine companies at which there has been a greater amount of detail. There is nothing which has not been more or less highly satisfactory, and as you know we are dependent on those companies, and the management of those companies is very much in the hands of those who are sitting at this Board, and I am satisfied without having gone into greater detail our affairs throughout the year have been on the whole satisfactorily, and I see no reason why that ought not to continue.

The Consolidated Telephone Construction and Maintenance Company (Limited).

An adjourned meeting of the shareholders of this Company was held at the Cannon-street Hotel, on Friday last, to receive the report of the committee of investigation appointed by the shareholders at the ordinary general meeting of the Company held on the 23rd May, 1881. Mr. Charles L. W. FitzGerald, chairman of the committee, presided.

The Secretary (Mr. C. Curtoys) read the notice convening the meeting. The report of the committee, and the circulars issued by Colonel Gouraud, the Hon. Howard Spensley, and Mr. P. Carnegy, in answer thereto, were taken as read.

The Chairman then addressed the meeting at great length on the various documents which had been circulated amongst the shareholders. He began by saying that the committee of investigation had decided to accept the resignation of Colonel Gouraud from the Board of the Consolidated Company. He had written to that gentleman on the subject, and requested him to send in his resignation in writing. Colonel Gouraud had, however, failed to do so, for reasons best known to himself. He wished to make a few remarks on Colonel Gouraud's reply to the report. First, as to the allotment of shares. He found, from a minute of the 22nd April, 1881, that 15,000 shares were allotted to Sir Julius Vogel, 15,000 to Colonel Gouraud, 2,500 to Mr. Patrick Carnegy, and 2,500 to Sir Alexander Armstrong. He now understood that a great proportion of those shares were allotted to the various directors' nominees. The next remark he wished to make on the document in question was concerning the 95,000 shares held by Colonel Gouraud in the Edison-Gower-Bell Company, which he also copied from the official register. He discovered from the minutes that 175,000 shares were allotted as follows:—T. A. Edison 72,000, Colonel Gouraud 95,000, Mr. Bigelow 4,000, and Mr. Bell 4,000. The next thing that he need allude to was that Colonel Gouraud said he was not a director at the date of the formation of the Edison-Gower-Bell Company. Colonel Gouraud resigned on the 11th of August, and he (the Chairman) found from a minute that on the 10th of August there was a letter read from Colonel Gouraud dated the 5th of August, which showed that negotiations were commenced with the Edison-Gower-Bell Company, which he thought was cutting it rather fine. He would allude to Messrs. Spensley and Carnegy's remarks as he went on with his speech. The moment he saw that allotment he said to himself, "That is the downfall of this Company." He would not trouble the meeting with references to the fresh issue of capital. They all knew about that, and where the money went. As to the 4,000 telephone contract, he could only say that it was to his mind a most mysterious business. In plain English they, as shareholders of the Consolidated Company, paid Mr. Gower a very large sum of money for that contract. Mr. Gower of course handed on that contract to them, it might be in perfect good faith, and when their directors on the 7th October got uneasy about the gentlemen who contracted to take those telephones they began to press them, and when they did so they discovered that they could not get the telephones taken up. This went on, as they would see by the report, until the 14th of July, when the Board decided to issue a writ against Messrs. Biglow, Cargill, and Colonel Gouraud, and they did issue that writ; but they repented, and there was no record whatever to show what induced the directors to change their mind. He would like to hear from Mr. Carnegy what induced him to change his mind, and he would also like Colonel Gouraud to state why he could not fulfil the contract, because it appeared to him that they were perfectly ready to make the telephones and get a profit on them. These were points which ought to be cleared up. Speaking roughly, he was told that they had paid Mr. Gower between £25,000 and £30,000 for that contract, and they received back to compromise matters only £6,800 cash, which he could not regard as a very good bargain. The Chairman here read the resolutions come to in regard to the settlement on the 18th and 25th of August, and said that he would like to go a little deeper into the subject of the contract from a legal point of view. He need not say much about the Oriental patents. He did not know whether the shareholders understood the "very delicate and complicated character" of the contract which the Board could not see their way to carry out or enforce. He now came to the Edison-Gower-Bell Company. They knew that Sir Julius Vogel made that extraordinary agreement. Colonel Gouraud was on the opposition then, and he must give that gentleman the credit for having got very much the best of the bargain. The agreement was made in Paris. Colonel Gouraud was there, and so also was Sir Julius Vogel as well as others, but he did not know who they were. Perhaps Colonel Gourand could tell.

Colonel Gouraud said he was listening attentively, and would reply to everything touched on.

The Chairman characterised that agreement as something "too dreadful" to contemplate, and read the resolution from the minute book bearing on the subject, remarking that he had asked the Board of the Edison-Gower-Bell Company to give him a statament of what they considered their rights in those properties, and he was sorry to say that he had not received a reply.

Colonel Gouraud wished to call attention to a reply made on the day before the receipt of the Chairman's letter.

The Chairman said he had never seen the letter referred to.

Colonel Gouraud: That must be the fault of the secretary.

The Chairman said he would now pass on to a much pleasanter subject—the United Telephone Company. Provided people came for telephones more than they were doing, that business could be made to pay. That people would by and by apply for telephones was a certainty, but at present the business was not sufficient to make the factory a paying concern from that one particular source. He should here remind them that they did not buy the patent absolutely from Mr. Gower. They had paid

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that gentleman a sum of money, and they held the Gower patent for the United Kingdom in trust for the United Telephone Company. They were not the absolute possessors of the patent.

A SHAREHOLDER: Have you no interest in it?

The CHAIRMAN replied that they had an interest as long as their agreement lasted with the United Telephone Company. They would also see that the United Telephone Company paid them £25,000 if they terminated the agreement. He now came to the manufacturing account, which was a very difficult subject. He had been in his present position only for two months, and the business of the Company when he first looked into it seemed to be in a very bad way. He did not mind telling them that it was looking better now, and that they were doing a good deal of work. He went to the works every morning at 8 o'clock, and they had got a man there who told him that he would make the business pay. His own impression was that it could be made to pay a little, though not very much at present. The debts, according to the report, were £3,180. He did not know how he had done it, but he had managed to reduce that amount to £2,400. The accountants told him that he had made a mistake in saying that the sales showed a loss of £6,253 for 1884. He was very glad to hear it. He hoped he had made the mistake. It would be far more satisfactory to him to know that they were making a profit and not a loss. He ought also to say that Mr. Griffiths at the outset of the Company made Sir Julius Vogel put on one side £6,000 to meet some questionable profit. That was a very important point in favour of the auditor.

A SHAREHOLDER: What to meet?

The CHAIRMAN: Some doubtful profit. Sir Julius Vogel wanted to divide the profits all at once. As to the issue of fresh capital, he thought it would have been far better if the directors had taken the shareholders into their confidence, and told them the exact position of their affairs, because he really thought the business was a fairly good one, as far as he could judge; and if they had gone to the shareholders, and said, "We can make a profit on the Austrian concession and the River Plate, and we can see our way not to lose money on the manufactory," they would have said, "All right, gentlemen, we will give you money; go on." If he had been a shareholder he would certainly have said so. It seemed to him that the joint account was a very unfair one to their Company. And as to the Oriental Company, the explanation of Messrs. Spensley and Carnegy, "that that Company stipulated at the outset that no payment should be made by the Oriental Company to the Consolidated Company for goods supplied until payment was received by them," seemed a peculiar arrangement; because, suppose the goods were kept hanging about unsold for years, and they did not get payment for those goods, the Oriental Company were not to pay the Consolidated Company any money at all. His idea was that they should try and arrange with the Oriental to work on a system of royalties. It seemed to be a much fairer way of doing business. Sir Julius Vogel was quite right to ask for money to go out to Australia, but he thought that that gentleman might have waited for profits before taking the second £250, a sum which he thought the Company was justified in demanding back. Mr. Power's commission had been already explained. As to the Articles of Association, he thought they ought to be revised [Col. GOURAUD: "Hear, hear."]. He said that with regard to all the companies, because their articles were very nearly all the same. As to the capital account, he thought it must be reduced. He saw no way out of that at all. They had not sufficient assets to represent their capital, and, as they were aware, even if they made a dividend it could not be declared while that was the case. He also suggested that an able accountant of the name of Mackay should be asked to go through all the books, and see whether the Company could claim any money from anybody. Seeing the magnitude of the solicitors' bills (which he personally had not yet examined), he recommended that they also should be closely scrutinised. On page 13 the committee placed before them a table of the possible dividends to be divided during the period ensuing from that date to July, 1885. He saw no reason to doubt that the table would prove a correct one if the figures that had been given to him were accurate, and if his suggestions were carried out as to pushing the Austrian business. He had gone into the River Plate business, and it seemed to him to be a good one. The fact was, as he stated on page 15 of the report, that, combining £33,650 amount of shares issued, and the £28,000 debt due to the Consolidated, the amount earned last year was about 11 per cent. net on the £61,650. He thought there were a good many of them who would like to earn that on their business. The only other remark he wished to make in this connection was as to the expenses. The directors' fees were £1,117, office charges £759, law expenditure £147, and interest £473. Now that seemed to be a very high figure for directors' fees, and after all said and done the business was not managed in London, but in the River Plate. Concerning the Edison-Gower-Bell Company, about which he had not said much, he did not know whether the following suggestion would meet the approval of the shareholders. As that company had apparently put into the business only a few hundreds for the Portuguese concession, and the Consolidated had provided £15,000 as working capital, giving the Edison-Gower-Bell Company credit for three years for a further sum of £10,000, it occurred to him that they should demand from the Edison-Gower-Bell Company debentures for that £15,000, or failing that, let the Edison interest put in £25,000, and let them go on and work that business and push it in Portugal. The Consolidated should have bills for that indebtedness. We have got them. The exchanges were working at a profit, small as they were. They had only 600 subscribers, and if they absolutely owned the business, and there were no London expenses, it would return them 9 per cent. They now came to the Austrian concession, which, after all said and done, was what brought about the crisis. When they first joined the Board there was a terrible personage of the name of Wessely, with a formidable account to settle amounting to £10,000, and they had about £100 to settle it with, and the original Board seemed very much alarmed at Mr. Wessely coming forward with his claim. Well, he liked to face things, and he said, "Let Mr. Wessely send in his account." After some little pressing that gentleman came over to London, and he found him a very nice person indeed, and solely actuated in trying to get the Austrian business to a paying basis. Their manager, Mr. Krause, came with him. Mr. Krause's accounts were kept in the most perfect manner, and he (the Chairman) believed if they put money into the Austrian business it was possible it would some day pay better than the River Plate. Colonel Gouraud went to Austria. He had made a long statement about that which he (the Chairman) could not understand at the time, namely, about "limiting liabilities," and so on. But it was a most extraordinary thing, when he came to go into the matter, he found that Colonel Gouraud, instead of limiting liabilities, incurred a further burden by taking over four more small towns, which had caused him (the speaker) no small anxiety, because he could not see his way how those towns could be made to pay, having in them under a population of 60,000 each. Colonel Gouraud, in fact, made the Company pay £2,500, besides a sum in caution money for the arrangement. Altogether, they had spent about £5,000 on those small towns. He believed, however, from what Mr. Krause told him that they might ultimately be made to pay. He had gone closely into Mr. Krause's statement, and it seemed that there were a certain number of people waiting for telephones to be put up. Well, he could only say that as soon as he could send out those telephones those people would pay a subscription of £7 per telephone. Therefore it was clearly to the interest of the shareholders that the instruments should be despatched to that part of the Continent as quickly as possible. That was one of the reasons why he wished them to buy the River Plate shares to provide the working capital. To show them how good telephone business was, he might mention that of the nine towns where they had the concession three of them were absolutely at the present moment supporting the working expenses of the other six. Well, now he would tell them what was done in the case of Mr. Wessely's claim. On going through that gentleman's account it was found that there was about £7,300 owing to him by the Company.

A SHAREHOLDER: For what?

The CHAIRMAN replied that it was on account of wires and installations erected in the various towns. In other words, Mr. Wessely had spent money on account of the Consolidated Company, which the shareholders had to find, while the Company had a debt owing to them by the Austrian Company of about £24,800. Well, they agreed together that they would take debentures of the Austrian Company for the amounts, Mr. Wessely to receive £7,500, and the Consolidated Company £25,500. To his mind that was the most satisfactory arrangement they could possibly make, because by some peculiar arrangement there was a clause in the agreement by which the Consolidated could not wind up the Austrian Company, or at any rate the clause would have rendered it exceedingly difficult to do so. After having heard what Mr. Wessely had to say on the subject, it was thought far better in the Company's interests not to attempt to wind it up; and for this reason, that they had been so delayed in going on with the business in Austria that it was a question whether the Austrian Government would not have forfeited the concession, and taken it from the Company. They therefore accepted those debentures, and determined to send out more telephones to put the various stations on a paying basis. The reforms he proposed were the greatest economy in working, and the ordering of fresh stores only as they were required to fulfil contracts. When he arrived at the factory he found to his intense surprise a great pile of stores of all sorts which had accumulated for he did not know how long. That was not his idea of carrying on business. Some of those stores he had been able to utilise. The next thing he would propose was that there should be a reduction of directors' fees on all the Boards of the companies, and that there should be three directors on the River Plate Company, three on the Austrian Company, and three on the Edison-Gower-Bell Company, and that those nine directors should constitute the Board of the Consolidated. He knew perfectly well that three directors could do the business of those companies abroad. If any very difficult question cropped up it could be decided by the nine directors of the Consolidated Company. He then pointed out that under the Articles of Association the River Plate Company was pledged to pay to its directors £1,200; the Austrian Company, £1,200; the Chairman of the Edison-Gower-Bell, £250; and whatever the shareholders chose to give to the directors; and the Consolidated, £2,000, making in all £4,670. Those amounts he proposed to reduce as follows:—The River Plate, £500; Austrian, £500; the Edison-Gower-Bell, £300; and the Consolidated Company, £1,500, making a total of £2,800 for directors' fees. He would detain them but for a minute or two more to call attention to the Edison Gower-Bell balance-sheet. There was a certain £1,000 there which he had not got a satisfactory explanation about. Messsrs. Spensley and Carnegy alluded to it, but their statement was not convincing. He found that there was a further sum of £833 on account of the Italian expenses. He had gone into that and discovered that the items for that were, for goods sent to Italy, £169; for goods sent to Rome, £217; and Italian caution money, £493. What was the explanation? Why did they send goods to Italy, and why did they pay caution money? There might be a satisfactory explanation, but it had not been forthcoming. They would see also that there were very heavy expenses in connection with the European Telephone Company—£3,380. They would hardly believe that that was spent in advertising. He thought he saw his way to put the Austrian business into a paying condition. He had told them also that the River Plate was paying, and that the Edison-Gower-Bell would return, he believed, with reduced expenses, a small sum of money. But they must have funds from some source or other, and it occurred to him that the way to

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meet the difficulty was that the shareholders should come forward and take up some of the River Plate shares. He was perfectly ready, as well as his friends on the committee, to take up their fair proportion. Personally, he was willing to take 100 of them. A report of the meeting would be sent to the shareholders, with an application form for River Plate shares, and he hoped it would meet with a generous response. He concluded by moving "That this meeting adopt the report of the committee of investigation, and authorise the expenditure incurred in legal expenses, printing and otherwise, in connection with the committee of investigation."

Mr. BUCKINGHAM seconded the motion, and bore testimony to the zeal of Mr. FitzGerald in his efforts to place before the shareholders the real position of the Company. Although they might not all clearly understand the report, it was evident that there had been some roguery somewhere, and the committee having gone thus far with their inquiry, he suggested that they should be further empowered to institute the legal proceedings recommended in the report.

Colonel GOURAUD, while exonerating the Chairman from any desire to prejudice him in the eyes of the shareholders, thought it necessary, because of the frequency with which his name had been dragged into the Chairman's speech and the report, to make certain personal explanations, lest the shareholders might put a wrong interpretation on any of the remarks that Mr. FitzGerald had made. He then proceeded to say that he felt it due to himself, while still adhering to his wish, as stated on the 23rd of May, to retire from the Board, to be present at this meeting as a director of the Company. As to those things which the Chairman had referred to him (Col. Gouraud) for explanation, he would merely say that he was perfectly able and willing to explain everything which originated with the Board while he was a member of it. Further than that, it would be out of place for him to go. While acknowledging the difficult nature of the task which the committee of investigation had had to perform, he reminded the meeting that he himself seconded the election of three of the gentlemen forming it, although they were strangers to him, and he could not help saying that had they been a little more frank and not above receiving information the directors might have greatly aided them in their labours. He then pointed out that the Chairman did not read the correct minute as to the allotment of shares which took place on the 26th of April, the minute as to which he accordingly read. There had not been a farthing drawn for fees from the Austrian Company, and as to the River Plate Company, although the directors had had money constantly passing through their hands, they had received no fees since April last. In the matter of the settlement with the Austrian Company, he reminded the meeting that it was the result of negotiations extending over a year and a half, although the report made it appear that it was effected exclusively by the committee. The inclusion of the four Austrian towns which had been referred to was a *sine quâ non* of the whole scheme.

The Hon. HOWARD SPENSLEY and Mr. P. CARNEGY very briefly addressed the meeting, and an animated and protracted discussion ensued, during which several amendments and counter-amendments were proposed.

Finally, on the motion of Mr. PITT COBBETT, seconded by Mr. GERMAINE, the following amendment was carried unanimously:—"That the shareholders, whilst approving the action of the committee, refer the matters dealt with in the report to the committee for a further and more specific report—1. As to the advisability of taking proceedings against those concerned in the various transactions referred to in the report, and including the reduction and taxation of the solicitor's expenses. 2. As to an alteration in the Articles of Association. 3. As to the consolidation of the Boards of the various companies, and changes recommended in the directorate and officials of these companies."

On the motion of Mr. BUCKINGHAM, seconded by a SHAREHOLDER, it was agreed to add Mr. Germaine to the committee.

Mr. SPENSLEY and Mr. CARNEGY announced their intention to retire from the Board if it was the wish of the shareholders that they should do so.

Mr. GRIFFITHS, of the firm of Messrs. Deloitte, Dever, Griffiths, and Co., was appointed one of the auditors of the Company for the ensuing year, and the meeting was then adjourned until a further report shall be received from the committee.

An adjourned extraordinary general meeting was subsequently held, Mr. FitzGerald presiding.

The SECRETARY having read the notice calling the meeting,

The CHAIRMAN moved the following resolution:—"That the action of the Board with reference to the settlement of the accounts of the River Plate Telephone and Electric Light Company (Limited) is hereby approved and confirmed, and that the arrangement made by the River Plate Telephone and Electric Light Company (Limited) is hereby adopted, and the directors are authorised to carry the same into effect, and take all necessary steps for that purpose."

Colonel GOURAUD seconded the motion, which was unanimously agreed to, and a vote of thanks having been accorded to Mr. FitzGerald for presiding the proceedings terminated.

Cuba Submarine Telegraph Company, Limited.

At a meeting of the directors of this Company on Wednesday the audited accounts for the half year to June 30 were submitted, and it was resolved, after providing for the dividend on the preference shares, and placing £1,266 to the reserve fund, to recommend the payment of a dividend on the ordinary shares at the rate of 9 per cent. per annum, free of income tax, leaving £367 to be carried forward.

The Anglo-American Telegraph Company.

Report of the directors to the ordinary general half-yearly meeting of the proprietors, to be held at the City Terminus Hotel, Cannon-street, E.C., on the 6th August, at 12 noon. The total receipts from the 1st January to the 30th June, 1884, including a balance of £657 4s. 1d. brought forward from the last account, amount to £231,892 18s. 2d. The traffic receipts show a decrease as compared with the corresponding period of last year of £13,775 consequent upon continued depression of trade between Europe and America. The total expenses of the half year, including repair of cables, &c., as shown by the revenue account, amount to £49,389 6s. 9d. The directors, under the powers conferred upon them by the Articles of Association have, before declaring the net profits, set apart the sum of £75,000 to the renewal fund, leaving a balance of £107,503 11s. 5d. One quarterly interim dividend of 12s. 6d. per cent. on the ordinary stock, and of 25s. per cent. on the preferred stock, was paid on the 1st of May, 1884, absorbing £43,750, and a second quarterly dividend of 17s. 6d. per cent. on the ordinary stock, and £1 15s. per cent. on the preferred stock, will be paid on the 1st August, 1884, absorbing £61,250, leaving a balance of £2,503 11s. 5d. to be carried forward to the next account. The Company's repairing steamship "Minia" has been engaged during the half year in repairing the 1880 cable, broken off the coast of Ireland; the 1869 cable, broken off Brest, and St. Pierre Miquelon; the Duxbury cable, broken at the same place; and the South Placentia cable, broken at a distance of ninety miles from Placentia N.F. She has also been engaged in the repair of the Direct U.S. Cable Company's cable, between Torbay and Rye Beach, having been chartered to that company for the purpose. The Company's entire system of cables is now in good working order. At the general meeting held in February last a resolution was passed by a majority of the proprietors present, recommending the directors to reduce the yearly contribution hitherto placed to the credit of the renewal fund. The resolution did not state the amount of reduction proposed, but from the discussion which followed the meeting appeared to be desirous of reducing the yearly contribution to that fund from £150,000 to £100,000, or less. After very careful consideration of the proposed reduction in connection with the condition of the cables, their present age, and probable life, and taking the most reliable opinions which could be procured on the subject, the directors have arrived at the conclusion that for some time to come no diminution can be made without great injury to the prospects and property of the Company, and seriously jeopardising the proportion of gross receipts accruing to the Company under the existing joint purse agreements. The directors look with confidence to the great body of the proprietors for their co-operation and support in the maintenance of the renewal fund, upon the sufficiency of which the whole existence of the Company depends. The Commercial Cable Company, promoted by Messrs. James Gordon Bennett and J. W. Mackay, appear to be actively progressing with their cable-laying operations, so that at least one cable may be expected to be opened almost immediately. It is difficult to realise the fact that two persons could be found able and willing to embark so large an amount of capital as is required in such an enterprise as the laying of two Atlantic cables, and to accept the risk, anxiety, and responsibility incident to their working and maintenance without any reasonable prospect of profit. No information has yet been obtained as to the tariff at which the new cables are to be worked. By the death of the Hon. Robert Grimston, which occurred in the month of April last, the directors have lost an esteemed friend and valued colleague. His long connection with this Company, and his great experience in the management of analogous undertakings, acquired as Chairman of the Electric Telegraph Company, and first Chairman of the Indo-European Telegraph Company, rendered his services of much value to the Board. Monsieur C. Crapelet, of Paris, has resigned his seat at the Board, as he was unable to attend its meetings in the manner prescribed by the Articles of Association. It is not proposed to fill up either of these vacancies, and as the number of directors is decreased, the Board resolve to reduce the fees by £500 per annum.

Submarine Telegraph Company.

Report of the directors to be submitted at the meeting of the proprietors held at the Company's offices, 2, Throgmorton-avenue, E.C., on Aug. 1, at 1 p.m.:—The accounts for the six months ending 30th June, 1884, show that the gross receipts amounted to £62,757 11s. 11d., which is less than the sum received in the corresponding six months of 1883 by £1,574 11s. This reduction is attributable to the reduced length of the messages transmitted; in the six months there were transmitted 40,410 more messages, but the number of words transmitted was 342,016 less than in the six months ending 30th June, 1883. In the first six months of 1884 the average length of a message was 12·04 words, whereas in the some period of 1883 it was 12·65 words. The total expenses show, on the other hand, an increase of £614 12s. This arises partly from an increased sum that the French Administration has charged for French clerks working the circuits between the French coast stations and London, and partly from additions to salaries of clerks and others in the employment of the Company. The net result of the business for the six months enables the directors to add to the reserve fund £7,830 9s. 1d., and to recommend a dividend at the rate of 13 per cent. per annum, carrying over a balance of £170 6s. 11½d. The directors have frequently had occasion to refer to the unsatisfactory condition of the cables between England and Holland belonging to the English Government and worked by this Company, and they took advantage of a favourable opportunity to make urgent representations to the Post Office on the subject. They have now much pleasure in reporting that the Government has laid down an excellent new cable, containing four conductors, between England and

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Holland, which is to replace the North Zandvoort cable, and that the South Zandvoort cable will hereafter be thoroughly overhauled by the Government. The directors trust that this improved communication will produce a satisfactory increase in the Dutch traffic. All the cables worked by the Company are now in good working order.

Anglo-American Brush Electric Light Corporation.

The following *ad interim* report has been issued to the shareholders of this Company:—

In accordance with the desire expressed by several shareholders, the directors have pleasure in submitting a short report on the business of the Corporation during the six months ended 30th June. The shareholders are already aware that the proposition of the Board to reduce the capital of the Corporation was unanimously adopted by two general meetings, and that the special resolution on this subject was in ordinary course sanctioned by the Court. An application has been made to the committee of the Stock Exchange to quote in the official list the new in place of the old denomination of shares, and it is expected that the application will shortly be granted. In accordance with the suggestion contained in the annual report, which was approved by the general meeting, the directors gave the holders of partly paid shares the option of making their shares fully paid before the 1st June, and this option has been exercised by about 100 shareholders, who have paid in the aggregate nearly £8,000. The directors are glad to be able to inform the shareholders that during the past six months further considerable progress has been made in perfecting the manufactures and in developing the business of the Corporation. The excellence of the apparatus supplied by the Corporation, both for arc and incandescence lighting, is now generally recognised, and the Corporation stand high in the estimation of the public, not only as manufacturers of the highest class electric lighting plant, but also as contractors for electric lighting installations. The Corporation have been successful in establishing the reputation for high efficiency of their Victoria dynamos and lamps for incandescence lighting, and their especial suitability for the purpose of lighting ships, contracts having been obtained among others from the Admiralty, after severe competitive tests, for fitting up the following of Her Majesty's ships of war with the incandescence light: — "Colossus," "Triumph," "Raleigh," "Bacchante," and "Conqueror." Among the other important work undertaken by the corporation may be mentioned a provisional installation of three 500-light dynamos at Buckingham Palace, the supply of the machines for lighting the Parliament Houses at Melbourne, and the exclusive lighting of the Forestry Exhibition at Edinburgh. Although, owing to the continued depression in electric lighting generally, the volume of business effected during the past half year has not been so large as was hoped for, yet it is a satisfactory feature of the business that shipments have been made to nearly all quarters of the globe, and that there is a continuance of orders from distant countries. In consequence of the liquidation of the Metropolitan (Brush) Electric Light and Power Company, the Brush and Lane-Fox licences for the important district occupied by that company have reverted to the Corporation, and the directors anticipate a considerable accession of business from this cause. The directors are giving their earnest attention to the question of establishing agencies in countries and places where the interests of the Corporation are not already protected by local subsidiary companies, and it affords them much satisfaction that their efforts in this direction have met with success. They have granted the sole agency for the German Empire to a firm who are able to bring adequate capital and powerful influence to bear upon the development of electric lighting in Germany, while agencies have been granted to influential persons in other European and transatlantic countries. The directors regret to have to inform the shareholders that the appeal against the judgment which was given in favour of the Corporation, about the time of the general meeting, in the action brought by Messrs. Muir and Co. for £736, the price of a machine ordered by the Corporation as long back as 1882, but refused on the ground that it had not been completed within the specified time, has been decided against the Corporation. The South Eastern Railway Bill, 1884 (various powers), has passed both Houses of the Legislature, and the question of whether the railway company shall take the whole or only a portion of the Corporation's Victoria Works, and the compensation to be paid, will be decided under the terms of the Act, when the South Eastern Railway Company acquire additional land for widening their line at this point, as is now in contemplation. The half-year's working shows a net profit on trading, after including exceptional law charges, and after making provision for all book losses and depreciation of property. This result compares very favourably with the trading account of the previous year, and warrants the hope that, with even a partial revival of electric lighting enterprise, the Corporation will be able to make fair returns on the capital subscribed. In conclusion, the directors feel that there is ground for congratulation in the fact that at present not only are all charges, ordinary and exceptional, met by revenue, but that the financial position of the Corporation is such as to enable the Board to undertake important contracts which they have in view, involving further expenditure of capital, without asking the shareholders to provide additional supplies.

PRICE FOURPENCE.

STATE MONOPOLY or PRIVATE ENTERPRISE?
By
SIR FREDERICK BRAMWELL, F.R.S.,
Vice-President Inst. Civil Engineers.
Published at the Central Offices of the Liberty and Property Defence League, 4, Westminster-chambers, London, S.W.
1884.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. July 30.		Business Done Week Ending July 30. Highest.	Lowest.
Anglo-American	31½,	32½	33½	32½
Do. Preferred	56½,	57½	59	56½
Do. Deferred	7,	7½	7½	—
Brazilian Submarine	9⅞,	10⅛	10	9⅞
Cuba	10,	10½	10⅜	10 5-16
Do. Preference	16½,	17½	17¼	17
Direct Spanish	4½,	5	—	—
Do. Preference	14¼,	14¾	—	—
Direct United States Cable	9⅝,	9⅞	10⅛	9¾
Eastern Telegraph	10⅞,	11⅛	11¼	11
Do. 6 per Cent. Preference	13¼,	13¾	13⅞	13½
Do. 5 per Cent. Debentures, 1899	104,	108	106½	—
Eastern Extension	11⅜,	11⅝	11 9-16	11 7-16
German Union	9,	9½	9⅛	9⅛
Globe Telegraph and Trust	6¾,	7	7	6⅞
Do. Preference	12⅜,	12⅝	12¾	12½
Great Northern	13½,	13¾	13⅞	13½
Indo-European	30½,	31½	31	—
Mediterranean Extension	—	—	—	—
Do. Preference	—	—	—	—
Reuter's	8,	8½	8⅛	8
Submarine	158,	162	162	159½
West India and Panama	⅞,	1⅛	—	—
Do. 1st Preference	6¾,	7¼	7	6⅞
Western Brazilian	5½,	5¾	5 9-16	—
Western Union 7 per Cent. 1st Mortgage	123,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	106	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	3-16,	5-16	¼	—
Oriental	⅛,	⅜	—	—
United Telephone	9¾,	10¼	10⅜	9⅞

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1¾,	2	1 15-16	1 9-16
Do. (fully paid)	3½,	4	3¾	—
Hammond Light (£3 15s. paid)	⅜,	⅝	½	⅜
Eastern Electric (£4 paid)	—	—	—	—
Swan	¼,	½	7-16	⅜
Maxim-Weston	⅛,	¼	⅛	—

MISCELLANEOUS.

Telegraph Construction	31½,	32½	32½	—
India Rubber, Gutta Percha, and Telegraph Works	21½,	22½	22¼	22

CIVIL SERVICE COMMISSION.—EXAMINATION for ASSISTANT EXAMINERSHIPS in the Patent Office (21-25), 29th August. Salary £250 to £400.
The date specified is the latest at which applications can be received. They must be made on forms to be obtained with particulars from the Secretary, Civil Service Commission, London, S.W.

UNIVERSITY COLLEGE, BRISTOL.
The Council are prepared to receive APPLICATIONS, on or before the 16th August, for the post of DEMONSTRATOR in EXPERIMENTAL PHYSICS.
For further information apply to
ALFRED E. STOCK, Registrar.

SALE BY AUCTION, at the office, and through the medium of, Mr. SEGOND, Notary, of Paris, Rue Laffite, No. 7, on the 20th AUGUST, 1884, at 2 o'clock, of FOUR LOTS of LETTERS PATENT for an Invention patented in France, Germany, England, and Italy for the ELECTRIC LIGHTING of RAILWAY CARS, BOATS, and other vehicles (Tommasi's system). Starting prices: French, German, and English patents, each 25,000 francs; Italian patent, 20,000 francs. 5,000 francs to be deposited beforehand for each lot.

CONSULTATION and TUITION.—An experienced Electrician gives TECHNICAL ADVICE and ASSISTS INVENTORS at moderate fees. Evening Class now forming for Electrical Engineering at Highbury Institute, N. For appointment and terms write M.S.A., care of *The Electrician* Office, 1, Salisbury-court, Fleet-street, E.C.

WANTED, SITUATION as ELECTRICIAN in an electric light company, or with firm of electrical engineers. Advertiser has had several years' practical experience in both arc and incandescent lighting. Good testimonial from last place.—S. G., 6, Samos-road, Anerley, near London.

PRICE, SONS, and COMPANY,
THE OLD STONEWARE POTTERIES
BRISTOL.
MANUFACTURERS of the IMPROVED HIGHLY GLAZED VITRIFIED BRISTOL STONEWARE, specially suitable for the manufacture of
Insulators, Primary and Secondary Battery Jars,
Combining the superior strength of stoneware, with a glaze free from metallic impurities, impervious to the action of chemicals, and smooth as porcelain.
POROUS POTS AND PLATES, ACID TAPS, WICKERED JARS.
Samples may be seen at International Health Exhibition, Stand 766.

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NOTES.

EARTHQUAKE IN BOSNIA.—Severe shocks of earthquake were felt at 2 o'clock and 3.45 p.m. on the 3rd instant at Foca, in Bosnia.

THE PHILADELPHIA EXHIBITION.—The buildings of the International Electrical Exhibition at Philadelphia are now finished, and exhibitors have begun to make arrangements for placing their exhibits.

TELEGRAMS TO FOOCHOW.—The Eastern Telegraph Company notifies that telegrams are accepted as usual for Foochow, the courier service between the landing place of the cable at Sharp Peak and Foochow having been resumed.

WORKS STRUCK BY LIGHTNING.—A telegram from Philadelphia, dated 5th August, says:—The Baldwin locomotive works, at Philadelphia, were struck by lightning, and partly burnt down, last night, the loss sustained being upwards of 200,000 dollars.

NATIONAL TELEPHONE COMPANY. — From an available balance of £6,672 the directors of this company propose to pay a further dividend of ¾ per cent. on the ordinary shares, making 1¼ per cent. for the past year. A balance of £3,297 remains to be carried forward.

ELECTRIC LIGHTING IN PORTUGAL.—The Companhia Portuguesa Electricidade has been formed at Lisbonne with a capital of 2,500,000 francs (£100,000) to supply electric light. A central station will be erected, and it is said that the company already have orders on hand.

THE PORTRUSH ELECTRIC RAILWAY.—On Saturday last the members of the British Medical Association concluded their meeting at Belfast by a series of excursions, many hundred members paying a visit to the Portrush Electric Railway, and travelling to the Giant's Causeway by it.

SOUTH EASTERN BRUSH COMPANY.—The petition presented to the Chancery Division of the High Court of Justice on the 24th April last, for confirming a resolution reducing the capital of this company from £100,000 to £51,000, is to be heard to-day (Saturday) before Mr. Justice Chitty.

ATHLETICS AND ELECTRIC LIGHTING.—So successful were the recent athletic games given at the Boston Union Grounds with the aid of the electric light that, says an American paper, it is determined to repeat the experiment. This method of avoiding the summer heat and glare promises to become very popular.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this Company during the month of July was 3,596, estimated to produce £3,200, against 2,929 messages, producing £2,755 in the corresponding month of last year. The traffic receipts for the month of April, estimated at £3,300, realised £3,401.

A MINER'S SAFETY LAMP.—Messrs. Shippey Brothers write to us, explaining that in the Lever competition for the best miner's safety lamp, the lamp sent in for competition by them as the London agents of Mr. Morgan was made according to Mr. Morgan's first patent, but that since it was taken out great improvements have been made by the patentee.

OVERHEAD WIRES IN NEW YORK.—Dr. N. S. Keith stated at a recent meeting of the New York Electrical Society that the number and extent of aërial wires in New York had been largely overstated. On reliable authority he found that the telephone companies had about 6,000 or 7,000 miles, the Western Union about 3,000, and the other companies in proportion.

THE FRENCH ELECTRICAL POWER STORAGE COMPANY.—Vice-Chancellor Bacon made an order on Saturday last for the winding up of this company on the petition of the Faure Electric Accumulator Company. It was stated in court that the proceeding was rendered necessary by the frauds of M. Phillippart, whose name has been so intimately associated with disaster to electric lighting and accumulators.

ANOTHER EXHIBITION.—An exhibition which includes many electrical appliances, and which is lighted by electric lamps, was opened at Steyr, in Upper Austria, on Saturday last by the Archduke Charles Louis. The motive power for the electric light machinery is derived from water wheels, and we hope that the opportunity will be taken of obtaining reliable figures as to the cost and effectiveness of this much-talked-of source of energy.

ELECTRIC LIGHTING IN KENSINGTON.—At the last meeting of the Kensington Vestry, on the recommendation of the Works Committee, it was decided to revoke the order granted to certain persons for the purpose of lighting by electricity a certain district in South Kensington, the undertakers not having complied with the Orders Confirmation Act in depositing the necessary sum (£12,000) to the satisfaction of the Board of Trade.

THE TELEGRAPH IN IRONWORKS.—The monster works of Krupp at Essen, the birthplace of many a score of cannon, employ no less than 20,000 workpeople. There are also in use there 439 steam boilers, and 450 steam engines representing 185,000 horse-power. In addition to 40 miles of rails, 28 locomotives, and 69 horses, Herr Krupp has pressed into his service 40 miles of telegraph wire, which run between 35 stations, and 55 Morse instruments.

ELECTRIC LIGHTING IN LAUSANNE.—The Swiss Electrical Company have lighted the Cantonal Hospital at Lausanne on the Edison system. The installation comprises 236 lamps and three dynamos, the latter being driven by three turbines. The company also have a central station in the same town, where there are two dynamos driven by two turbines of 35 horse-power each. These supply current to 280 lamps. There are 72 subscribers to the company's system.

OVERHEAD WIRES IN LONDON.—The Kensington Vestry have decided not to entertain the request of the Wandsworth Board of Works to contribute towards the expenses of an appeal in the recently heard case of the Wandsworth Board *v.* the United Telephone Company. They have, however, resolved to concur in a proposition of the Marylebone Vestry, to request the Government to bring in a Bill giving local authorities control over wires in their several districts.

ATMOSPHERIC PHENOMENA.—The daily papers of Tuesday last stated that some gorgeous sunlight effects had again been observed over the Yorkshire Wolds. For several nights past the sky had been one mass of richly-blended colours, commencing at the horizon with a broad belt of deep yellow light, and then band above band of orange and purple, the latter colour predominating in horizontal streaks, whilst up to the zenith the heavens were flooded with a magnificent glow from the setting sun.

A METEOR.—The Philadelphia correspondent of *The Times*, telegraphing under date August 1, says:—"A magnificent

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meteor was observed at 2 o'clock this morning at the Redhouse Observatory, in Phelps, New York, moving from near the zenith towards the west. It was unusually brilliant, illuminating the country like the electric light, and leaving a train of sparks 40 deg. long, which was visible for several minutes. It was seen through the telescope to roll and curve like a wreath of smoke, with a slow motion northward."

TELEGRAMS FOR CHINA.—The Great Northern Telegraph Company announce that, the courier service from the landing point of the Shanghai-Foochow cable up to the latter town having been stopped by the Chinese authorities, telegrams for Foochow as sent hitherto will only be accepted at sender's risk. Telegrams for Foochow may, however, be forwarded *viâ* Shanghai by means of the Chinese land lines. The rate for telegrams forwarded in this manner, which should be marked "*viâ* Chinese land lines" (these words are not charged for), is 10s. per word.

TELEPHONIC EXPERIMENTS.—A Reuter's telegram, dated Rome, Aug. 4, says:—"Some interesting experiments were made with the telephone yesterday evening between this city and Florence, Signor Genala, the Minister of Public Works, who was present at this end, several times communicating with Signor Gadda, the Prefect of Florence, at the other end. The two telephones, which were connected by ordinary telegraph wires, worked successfully enough, although the buzzing of the thermo-telluric (*sic*) currents precluded a perfectly distinct transmission of the voice. On the other hand, a cornet played at the Florence end was very well heard here."

ELECTRIC LIGHTING AT BRIGHTON.—At the third concert of the season given at the Pavilion, Brighton, last week, incandescent lamps were very largely employed for illuminating the exterior of the building as well as the grounds. The pinnacles and ornamentations of the Pavilion, which lend themselves readily to illuminating purposes, were picked out with lamps, and the trees and lawns were adorned in the same way. The result was very pretty. About 600 twenty-candle Swan lamps were used altogether, and the whole installation was carried out by Mr. Magnus Volk, electrical engineer to the Brighton Corporation, with the success which always marks and attends his work.

BUSINESS NOTICES.—Messrs. W. F. Dennis and Co., of 101, Leadenhall-street, E.C., sole agents for Messrs. Felten and Guilleaume, of Mülheim-on-Rhine, inform us that they have now combined their Liverpool and Birmingham districts, and placed the conduct of the business under the management of Mr. Henry N. Cross, who will in future reside at Liverpool, but gives the whole district his personal attention.—Mr. H. C. Harold informs us that he has established himself at 30 and 31, St. Swithin's-lane, E.C., as a manufacturer's agent for the sale of every description of telegraph, telephone, and electric light material. Mr. Harold was until lately with Messrs. Johnson and Phillips.

IMPROVEMENTS IN ACCUMULATORS.—M. Paul Gadot has, says the *Révue Industrielle*, made several improvements in the Faure-Sellon-Volckmar accumulators, which have considerably increased their capacity. He obtains a duty of 13 ampere-hours per kilogram of lead, with a mean pressure of 2 volts. The current is very constant and the storage capacity is about 9,400 kilogrammetres per kilogram of lead. His lead electrodes are as usual covered with oxide, but their make is improved, and they do not dip in acidulated water but in a liquid, the composition of which is still kept a secret. This liquid, which has a depolarising action, facilitates the attack of the metal plates; it also permits of a greater or less duty being got out of the accumulator, according to the requirements of the moment.

ELECTRIC LIGHTS FOR LIGHTHOUSES.—The *Daily Telegraph* says:—"During the past week the lighthouse experiments at South Foreland reached an important stage, at which a committee of the Elder Brethren of the Trinity House were enabled to form a pretty correct notion of what will be the nature of their ultimate report upon lights. It has been found that by means of concentric lenses a light nearly as powerful as the electric can be obtained without the same amount of risk of failure, and at a comparatively small cost." This sounds unfavourable to the electric light, but whether it is gas or oil which has given the superior result mentioned our contemporary does not say. It would be rash to draw conclusions from a paragraph like the above, and we therefore give it as a piece of news merely, until more definite information is in our hands.

NEW CABLE IN SUNDA STRAIT.—The following notice has been issued by the Admiralty:—The Netherlands Government has given notice, dated 28th June, 1884, that a telegraph cable has been laid in Sunda Strait, from Nieuw Anjer (Merak), in Java, to Kalianda, on the eastern shore of Lampong Bay, Sumatra:—From the beacon with triangle on the shore at Nieuw Anjer the cable takes a direction N. 42° W., passing about one mile northward of Merak Island, where it is marked by two buoys. From the western buoy the cable is laid to pass one mile southward of Thwartway Island, and one mile south west of Hog Point to a position S. 71° E., distant 1¼ miles from the south eastern of the Tiga Islands. Thence it takes a northerly direction, and is marked by two buoys, situated respectively N. 51° E., distant 1¼ miles, and N. 14° E., distant four miles from the south eastern Tiga Island. From the northernmost of the two last-mentioned buoys the cable takes a N.E. by E., and E.N.E. direction to the beacon with triangle and the cable house at Kalianda. The buoys and beacons marking the telegraph cable are painted white; the buoys have the word "Kabel" on them, and are surmounted by an iron flag (Dutch colours), on which is the word "Telegraaf."

THE CANDLE-POWER OF LONDON GAS.—Dr. A. W. Williamson, F.R.S., the chief gas examiner of the Board of Trade, has reported for the information of the Corporation of London the results of the daily testings of the gas supplied in the City by the Gaslight and Coke Company during the past quarter. With respect to illuminating power, the average at Aldgate was 16·9 in standard sperm candles, at Cloth Fair 16·6, and at Salisbury-square, 16·6. In each case the average was higher than the parliamentary standard. At the King-street, Cloth Fair, testing station, the minimum was slightly below the requirements on the 15th May. At Aldgate the minimum was equal to the requirements, while at Salisbury-square it was slightly above them. As regarded purity, the gas had been wholly free from sulphuretted hydrogen. The average proportions of sulphur in other forms were, per cubic feet of gas, 10·4 at Aldgate, 9·7 at Cloth Fair, and 9·7 at Salisbury-square. These averages were less than the limit allowed, and the maximum amount recorded was also less than the quantity permitted. Ammonia had not been present during the quarter in the gas tested at the Aldgate and Cloth Fair stations. At Salisbury-square it appeared frequently, but only in slight quantities.

NEW CARBON BATTERY.—Messrs. Tommasi and Radiguet have brought out a new carbon battery. It is composed of a

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rectangular basin of porcelain, at the bottom of which is placed a carbon plate surrounded by a paste of peroxide of lead, forming one of the electrodes. The other electrode is formed by a second plate of carbon similar to the first, but containing in its upper part fragments of platinised retort carbon. These two plates are placed one on the other, and separated by a piece of parchment paper so arranged as to divide the basin into two perfectly separated compartments. To make the battery work, a small quantity of saturated chloride of sodium solution is poured into the compartments in such a way as on the one hand not to hinder the peroxide of lead too much, and the other so that the fragments of carbon covering the upper electrode shall be only partly in the solution. This battery, which works only when the circuit is closed, gives an E.M.F. of ·6 volt. The negative pole (the zinc of ordinary batteries) is formed by the carbon plate, which does not touch the peroxide of lead. If for the solution of chloride of sodium other salt solutions such as sulphate of ammonia, sulphate of soda, chlorhydrate of ammonia, or even weak sulphuric acid be substituted, the E.M.F. does not sensibly vary.

Provisional Orders.—The Board of Trade having had under their consideration applications from various electric lighting companies for a further extension of time within which to comply with the provisions under which the provisional orders were granted last Session for the electric lighting of the provinces, and of places outside the London area, they have decided to grant an extension of time to the 31st December next for the lighting of Croydon, Margate, Ipswich, and Sudbury, and until the 1st June, 1885, for the lighting of Birmingham, Redditch, and Walsall. They have, however, refused to further extend the time, already once extended, for the lighting of Gravesend, and this order will therefore be revoked, as will also the orders for the lighting of Cambridge, Folkestone, High Wycombe, Sunderland, and Wolverhampton. It may be stated that of the 25 orders granted to public companies last Session for lighting the provinces only 12 remain in force, and of these the companies holding the first seven orders above-mentioned have already had the time originally granted them to comply with the provisions of the orders twice extended, while in the case of the remaining five—namely, Canterbury, Maidstone, Lowestoft, Luton, and Rochester, the time had already expired, and the question of granting any further extension is still under the consideration of the Board of Trade. During the present Session not a single provisional order has been applied for by any company for lighting the provinces, nor have any applications for licenses been received, and of those which had previously been applied for, that affecting Colchester is the only one which has been proceeded with by the promoters.

Electric Lighting in Belfast.—As briefly mentioned in our notes of last week, the electric light was very extensively used in the Queen's College, Belfast, during the recent sittings of the British Medical Association. The magnificent library, which stands apart from the main building, was beautifully lighted (for the first time since its erection on account of the risk of injury to the books by the use of gas) by incandescent lamps arranged in a continuous line around the balcony, which brought out in a very fine manner the architectural design of the building. Two of the reading rooms attached to the library were also lighted by the same means, one serving as a small refreshment room, the other being the office of the editor of the daily journal. The main refreshment room, situated at the further extremity of the college, was illuminated by a large electrolier suspended in the centre of the room, while incandescent lamps also served to illuminate the corridors, cloisters and staircases, &c., while, on the night of the *conversazione* a row of 10 candle-power lamps was used with good effect as foot lights to the temporary stage erected in the library. The lighting of the main portion of the building was effected by arc lamps which were placed in the main hall of the college, the large examination hall, and the museum, while the grounds were also lit by the same means. Among various concerts, exhibits, experiments, &c., provided for amusement, the projection on the screen of the electric arc, as also the spectrum of blood by Professor Letts in the chemistry room, attracted a very large number of visitors. The current for the incandescent lamps (Victorias) was supplied direct from a Victoria dynamo, driven by a Clerk's gas engine, while the arc illumination was effected by "Belfast" lamps, and a series-wound, direct-current Newton dynamo, driven by a Marshall portable steam engine. Both lamps and machine, as also the carbons used, were of the latest and most approved make, manufactured by the Belfast Electric Appliances Company (Limited), by whom the entire work was carried out, under the superintendence of the manager, Mr. G. Annesley Grindle.

Thunderstorms in America.—An American paper gives the following summary of accidents from lightning which occurred during the first three weeks of July:—"The loss by fire in Brooklyn, at the furniture factory struck by lightning, was not less than 100,000 dols. In New England and in various parts of New York many houses were struck, while telegraph and telephone wires were frequently rendered useless. At Greeneville, near Norwich, Conn., on July 13, an electric bolt fell into the kitchen of the farmhouse of a Mrs. M'Donald. She felt no shock, but was astounded to see the iron sink detach itself from the wall, spin twice around the room, and fall in small pieces on the floor. At the same moment the stove and every piece of furniture in the kitchen were riddled, and the minute fragments were flung about the woman in a shower. A ground swell set the floor undulating, and the plaster fell from the walls over the ruined furniture. No other room was visited. Another bolt exploded in the street opposite Mr. Durfey's residence, half a mile away, moved his heavy granite door steps several rods up street, and smashed every pane of glass in the lower story front without touching the house. At Roaring Creek, Pa., the barn of a farmer was struck on the night of the 12th, and destroyed with all its contents, including valuable cattle, the loss amounting to 5,000dols. Two of the farmer's sons and another man were fatally injured while attempting to rescue the stock. Paterson, N.J., had a serious visitation on the 12th also, at midnight. The play of lightning on the wires was terrific, and balls of fire rolled along the car tracks in the streets. Forty wires were burned out at the central telephone exchange, and poles and fire alarm apparatus suffered damage. But the most astounding statement in connection with the display at Paterson is that, according to the newspapers, an electrician gravely calculated that the flash which played such havoc contained as much electricity as could be generated by 357,600 dynamos. The papers are all very precise as to the figures from this new style of lightning calculator, but they all omit any information as to the capacity of the dynamos. It seems to us that these occurrences and the scores of others recorded by the press within the month should direct attention to the desirability of using lightning rods, and rods that may be depended upon, of the right height, properly put up and well grounded." English reporters often lose their heads when reporting thunderstorms and their effects, but for

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tall talk their American brethren can, to be slangy, "lick their heads off."

TRAIN LIGHTING.—Among the many methods of lighting trains by incandescent lamps but few have stood the test of practice. Among the latter may, however, be placed what is known as the Stroudley-Houghton system, which comprises the utilisation of power from the axle of the brake van by an arrangement of belting and shafting on to the spindle of the dynamo; a dynamo of an E.M.F. as required; an accumulator of sufficient power to absorb the output of the dynamo when no light is required, and to add to such output the requisite supply of current when the whole of the lamps are on; and an apparatus which automatically excites the field magnets of the dynamo prior to the closing of the circuit, shuts it out of the circuit until the speed of the train is such as to create an E.M.F. in the dynamo sufficient to charge the cells, or when the speed is so reduced that the E.M.F. of the dynamo is less than that of the cells, then to cut the dynamo out of the circuit, as otherwise the cells would play back on to the dynamo. The apparatus also prevents any excess of current being generated in the dynamo when the train is running at an abnormally great speed. Another important feature of the apparatus is that it is automatically reversible, and consequently works no matter in which direction the train is going. The local train on the London, Brighton, and South Coast Railway fitted up with the Stroudley-Houghton system commenced public work on November 29th, 1883, and has, we are told, worked without cessation ever since. During the foggy weather the light was often burning from two or three o'clock in the afternoon until midnight, and yet never once was there any failure. The express train to Brighton, which has been newly fitted up, is so arranged that there are two lights to each compartment to prevent the possibility of a compartment being left in the dark owing to the breakage of a lamp. The present lamp glasses and holes in the roof of the carriage are also utilised, and the electric lamps may be removed and replaced by a man on the roof quite readily. The whole of the labour, discomfort, and dirt of oil disappear, equally so the waste of time and extra weight of material necessary for gas lighting. The installation consists of a specially modified form of Brush dynamo, a storage battery, twenty of the Electrical Power Storage Company's cells, and the Stroudley-Houghton automatic apparatus, the whole being fitted in a portion of the guard's brake van. Any direct current dynamo is utilisable. The connections between the carriages are so constructed that they may easily be uncoupled, and in slip carriages will do so automatically. At the present time the apparatus has been fitted only on to the usual undergear of English railway brakes where the axles are fixed, but the apparatus may be used with equal facility on the bogey frame, the arrangement of the belting being altered in a suitable manner. The patents for this system are the property of the Railway Electrical Contractors (Limited), of 4, Great Winchester-street, E.C.

ELECTRIC LIGHTING.—A correspondent, signing himself "A. S.," writes to *The Times* as follows:—"The question is being asked, with increasing frequency, why electric lighting does not progress more rapidly. All the experiments made in public thoroughfares and in private establishments prove the excellence of the light, and in the latter, especially in offices and warehouses, its immense advantage over gas, owing to the non-impaired purity of the air it maintains. On a dark, dreary winter's day, when lights have to be kept continually going, the difference in the air one breathes, as time passes, under one and the other system of lighting is such as only those who have experience of both can realise. Nevertheless electric lighting does not go ahead. Wherefore? I will tell you, and I trust the public through you. It is entirely the result of the Electric Lighting Act of 1882, which provides that only a 19 years' contract may be entered into. How is it possible that electric companies should be able to recoup themselves in 19 years for their outlay in plant, machinery, stations, laying of wires, &c., and make a fair and reasonable trade profit out of the price they could sell their light at? So long as there is no street lighting there can be no house-to-house lighting, because it is from the street wires that the accumulators, in which the electricity has to be stored for distribution in the houses, have to be charged. What gas lighting, street or house, would be possible were gas companies similarly handicapped? It is from the street mains that the supply of gas for house use is carried into the houses. Electricity, since it came into public notice a very few years ago, has passed through a serious ordeal. It was fastened upon by a horde of schemers as a means of gambling; bogus companies were promoted, and shares driven up to most extravagant prices. Then the other side, the wreckers, took their turn, and prices were driven as far below the mark as they had been above it, with this advantage, however, that the bogus companies and their promoters, or dupes, as the case may have been, have gradually vanished, and the provisional orders they took from the Government were not acted upon. The remaining comparatively few companies, there is no reason to doubt, are inherently sound, but the Electric Lighting Act of 1882, as already shown, debars them from giving to the public the undoubted advantages of electric lighting, which I believe could, if established on a large scale, be enjoyed at no greater cost than gas. If you will only start this subject, no doubt the public will soon be fully informed on the matter of cost and many other matters of detail by those better acquainted with the *minutiæ* of the question than I am. No doubt the Government are fully aware of the circumstances I have endeavoured to place before you. Why, therefore, is nothing done to facilitate the progress of electric lighting? Can it possibly be that every step in advance in electric lighting means an equivalent retrograde step in gas?—that the gas interest is enormous, every town and even every village in the land of any importance has its gas company, and almost every possessor of gas stock has a vote?"

TAPPING TELEGRAPH WIRES.—A contemporary said a few days ago that "Americans are always either ingenious or enterprising." We think both ingenuity and enterprise might properly be assigned as attributes of the heroes of the following story, though their ingenuity and enterprise might have been more legitimately employed if not more advantageously. The story is taken from the *Electrical World*, of New York, and runs as follows:—"David Stewart, a lineman employed by the Western Union Telegraph Company, made the discovery, on the 14th July, that the line of that company at Coney Island had been tampered with, and at once made a searching investigation, which proved successful. He ascertained that two young men had engaged board at the Arlington House, at Coney Island, and had been assigned to rooms No. 35 and 36, which are situated on the top floor of the hotel. Stewart at once went to Chief of Police John Y. M'Kane's office and obtained his permission to have three trusted policemen accompany him to the aforesaid Arlington House. At the door of the hotel they met Captain Wise, the proprietor, who stated that two young men had engaged rooms at the hotel about two weeks ago. They asked to be given

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rooms on the top floor, as they preferred all the breeze that could be obtained at the island. The rooms were given to them, and they appeared to be well suited with them. Stewart then proceeded to Justice Stryker's office and obtained a search warrant. When he returned to the hotel he was accompanied to the rooms by the policeman and Captain Wise. Room No. 35 was the first to be searched. In this room nothing was found to confirm the suspicions which had been aroused in Stewart's mind. When the next room was searched the carpets were torn up, and when the search was about to be concluded Mr. Stewart happened to look under the bed. With a cry of joy he sprang to his feet and said: 'Now we've got it, just look under the bed and see the telegraph instrument.' The men looked under the bedstead and discovered that there was a full set of lineman's tools, and also four telegraph repeaters, which were of the finest quality and finish. They had wires attached to them that could be used under water. Over the bedstead in the ceiling was found a hole large enough to allow several telegraph wires to be put through. Inside of the washstand were found a complete battery, and everything that was necessary for a well-regulated telegraph office. The instrument and other paraphernalia were then taken to Chief of Police M'Kane's office, and the lineman notified him of the discovery which he had made. The instruments were used to tap the wires of the Western Union Company on race days at Monmouth Park and Chicago, and the two men would first receive the messages which gave the name of the winning horses in the various races, and would hold the message until one of the accomplices could go to the pool room at Paul Bauer's Club House and buy tickets on the horses which had won the race. In the course of half an hour or so thereafter the men would send in the original message, and as soon as the names of the winning horses had been placed on the bulletin the accomplices would go to the club house and have their tickets cashed. In this manner they made a heap of money. The men were notified by some of their friends that their secret had been found out, and they did not put in an appearance, but left for parts unknown. They are supposed to be the same parties who tapped the wires of the Western Union Telegraph Company at the Iroquois Hotel last year. The law as passed by the last Legislature makes the tapping of telegraph wires a crime, and the parties, if caught, are liable to imprisonment in the Penitentiary for five years and a fine of 500dols."

THE ELECTRIC LIGHTING ACT.—Mr. George Offor, the manager of the South Eastern (Brush) Electric Light and Power Company (Limited and Reduced), writes to the *Pall Mall Gazette* of Tuesday as follows:—"I am far from believing that the Act is perfect; it would be wonderful if the first attempt to legislate on the subject were so. I also think that in one respect, to which I shall refer presently, the Act itself has not been wisely worked by the Board of Trade; but, on the other hand, the public ought not to allow the Act to be made the scapegoat for all the shortcomings of electric lighting systems and want of efficient management. The terms of the Act and the rules made under it by the Board of Trade were well known when Mr. Arnold White, among others, applied for provisional orders. Why, then, did he fight so hard and successfully to obtain powers for his company in one of the best districts of London if he really believed that by accepting the conditions he was assisting in 'blindly throttling' the new industry? How should we fare if we had no Electric Lighting Act at all? It is true that at Hastings and Eastbourne central stations have been established and mains laid through the streets with the assent of the local authorities, and business is being carried on without reference to the Act of Parliament or Board of Trade, but it it doubtful, to say the least, if the local authorities possess supreme power to allow the streets to be disturbed for electric lighting purposes, and it is clear that in towns where the governing bodies are opposed to the electric light being introduced at all, it would be impossible to carry on the industry without an Act of Parliament. What, then, is really required is such a modification of the rules from time to time as the experience of practical working may render necessary; and, speaking from personal experience in connection with this company's work at Colchester, the Board of Trade appear to be fully alive to all this, and have met the requirements of our electrical engineers in a practical spirit. The provision of the Act which excites Mr. Arnold White's especial disfavour is that under which consumers are at liberty to use any lamp they please; but if the Edison claim—which they are now prosecuting in the law courts—be successful, this difficulty will be remedied by the inability of any one but Edison to supply an incandescent lamp, from which disaster the public may profoundly desire to be preserved! But, as a matter of fact, the consumer must use a lamp suitable to the current with which he is supplied, and this will practically limit him to those recommended by the undertaker. It cannot be in the interest either of consumer or undertaker to use an uneconomical lamp, especially if the storage system is employed, as it is clear that according to the amount of energy used in giving a certain quantity of light, so must be the charge for it. As to picking your customers, that, I take it, is impossible and undesirable in any general system of lighting. It is not likely that powers would be given to an electric lighting company to pick out all the plums and leave the rest of the consumers to get their light from the gas companies; nor would it be fair to the gas companies to compel them to supply the small consumers only. If both parties are relieved from the unprofitable trade, then what will this section of the public say to it? I am astonished to learn that, under the Edison system, it is necessary to pick your customers in order to make a large installation pay at the equivalent of 7s. 6d. per 1,000 feet of gas. At Colchester, where we are charging at the rate of 5s. for gas, the business will pay well with a supply of only 2,000 lamps with an average burning of 300 hours each per annum. The action of the Board of Trade to which I take exception is with respect to the 11th clause of the Act, under which licenses and provisional orders may be assigned with the consent of the Board of Trade. This power the Board of Trade decline to exercise, and, in consequence, provisional orders, which might be assigned to local companies, must be worked with the capital of the original undertakers, or a fresh Act of Parliament obtained to sanction the assignment. This decision of the Board of Trade has, I venture to think, done more to 'throttle' the industry than anything else; they probably feared the encouragement of speculation in provisional orders, but by withholding consent from all assignments not based on fair terms, all abuses of the kind could have been prevented. A great deal of work has, no doubt, been undertaken by electric lighting companies at considerable loss as a means of advertising their business. Mr. Arnold White recommends a reduction of the capital account of the electric lighting companies and a general fusion of interests. As to the first, I contend that the great need of the industry is more capital; and as to the second, it will be necessary to find which interests are identical before any fusion is possible. Systems diametrically opposed in principle could not be improved in working by amalgamation."

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THE ELEMENTS OF ELECTRIC LIGHT ENGINEERING.

BY E. C. RIMINGTON.

(CONTINUED FROM PAGE 272.)

If the reader does not happen to have a bridge at hand, and has no means of procuring one, he can easily construct the form known as the metre bridge thus

A German silver wire of, say, one yard in length and No. 22 B.W.G., is strained on a board between two terminals F and H (Fig. 8), and divided into 100 divisions by means of a scale marked on the board; D is a contact piece sliding along the wire, R is a fixed resistance taken as near the unknown

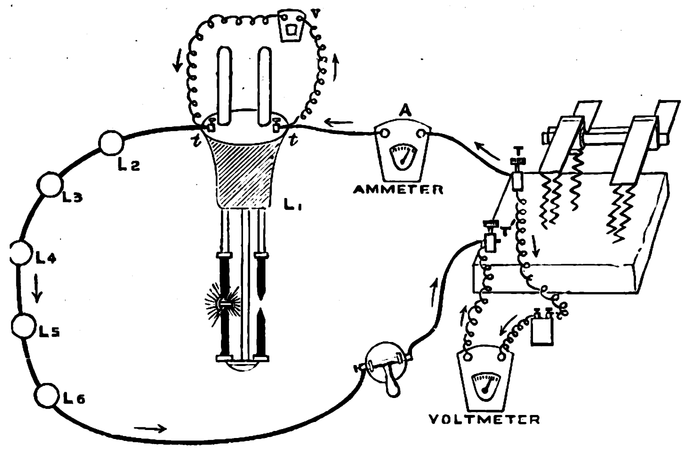

FIG. 8.

one, x, as possible, say three ohms, the connections being made as in Fig. 9. The wire F H forms the two arms A and B of the bridge, the resistances of which are in this case varied, while R is kept constant. The contact piece D is slid along the wire until the galvanometer gives no deflection when k_1 is depressed. Suppose when this happens D points to 20 divisions, then $B = 20$ and $A = 100 - 20 = 80$; therefore $x = \frac{80}{20} \times 3 = 12$ ohms, or to formulate, if d be the number of divisions indicated by the pointer,

$$x = R\left(\frac{100}{d} - 1\right)$$

Siemens's universal galvanometer contains a bridge of this form. Blackkurn's portable testing bridge described in *The Electrician*, Vol. X., p. 488, is also made partly up on this plan, and is an exceedingly portable little instrument for electric light testing work.

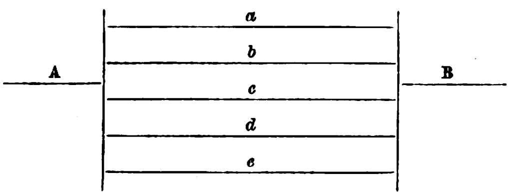

FIG. 9.

The resistance of any dynamo is best measured *immediately* after it has been running (care being taken to completely stop it, and to disconnect the external circuit), on account of the current heating the coils, and thus rendering their resistance slightly higher than it would be if they were measured when cold.

If we wish to measure the resistance of the field-magnets and armature separately in a series dynamo like Fig. 1, to obtain the former we must connect one of the lead wires from the bridge to T and the other to B; to obtain the latter connect one lead to T_1 and the other to B.

In a dynamo whose connections are similar to Fig. 5, the resistance of the armature can be found by connecting the leads to B and B_1; and to obtain that of the field-magnets connect one lead to B_1 and the other to T_1, the resistance found will be that of one of the field-magnets. Now disconnect the leads and connect them to B and T, which will give the resistance of the other field-magnet.

The resistance of the field-magnets can, however, be found more accurately when the dynamo is working by taking the E.M.F. at their ends and the current flowing through them, then dividing the former by the latter, as described further on.

The resistance of the external circuit, provided it contains no secondary batteries or voltameters, can be measured by the bridge in the same manner as the resistance of the dynamo.

If the circuit consists of a number of similar arc lamps in series, its resistance will be equal to the resistance of one of the lamps, as measured through its terminals by means of the bridge, multiplied by the number of lamps, to which product is to be added the resistance of the leads. If, however, the lamps are not all of the same resistance, we must add their resistances, and then add the resistance of the leads.

In the case of conductors or lamps (generally incandescent) in multiple or parallel arc, as Figs. 9 and 10, if r_1, r_2, r_3, r_4, &c., be the separate resistance of the conductors or lamps a, b, c, d, &c., then their joint resistance, or the total resistance of the arrangement, is equal to the reciprocal of the sum of the reciprocals of the resistance of each, or

$$= \frac{1}{\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} + \frac{1}{r_4} + \&c.},$$

which, in the case of four conductors or lamps in parallel arc

$$= \frac{r_1 r_2 r_3 r_4}{r_1 r_2 r_3 + r_1 r_2 r_4 + r_1 r_3 r_4 + r_2 r_3 r_4}.$$

If there are only two conductors or lamps having resistances r_1 and r_2, their joint resistance

$$\frac{1}{\frac{1}{r_1} + \frac{1}{r_2}} = \frac{r_1 r_2}{r_1 + r_2}.$$

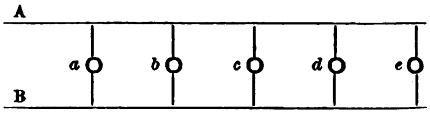

FIG. 10.

If the conductors in parallel arc are all of equal resistance, *e.g.*, a number of incandescent lamps, then the joint resistance of n of them

$$= \frac{1}{\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} + \ldots + \frac{1}{r_n}},$$

where $r_1 = r_2 = r_3 = r_n = r$.

Therefore, the joint resistance $= \frac{1}{n\left(\frac{1}{r}\right)} = \frac{r}{n}$, where r is the resistance of one conductor. So that, to find the resistance of a circuit composed of any number of similar incandescent lamps arranged in parallel arc, when no current is flowing through it, we measure the resistance of one of the lamps by means of the bridge, and divide the result by the number of lamps. Thus, suppose the resistance of one lamp as measured by the bridge was 100 ohms, and we had 50 of them arranged in parallel arc, the total resistance would be 2 ohms exclusive of the resistance of the leads.

Having measured the external circuit by means of a bridge, we obtain a result which, although valuable, is very different from the resistance that has to be overcome when the current is running. The resistance of the leads should remain constant, as their temperature should not be allowed to become

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raised by the current sufficiently to alter it. When, however, we come to the lamps, motors, or whatever we may be running, we find a great difference. Arc lamps have a really higher resistance when running, that obtained by the bridge measurement consisting simply of the resistances of the carbon rods and the coils of wire governing the working of the lamp, while the principal resistance in running is the resistance of the arc, which is chiefly composed of highly-heated carbon vapour and volatilised carbon.

Motors and secondary batteries have an apparently higher resistance, due to back E.M.F., while, on the other hand, the hot resistance of an incandescent lamp (or resistance when the current necessary to produce the proper candle-power in the lamp is flowing through it) is only about one-half the cold resistance as measured on the bridge.

Let us now take some measurements on a circuit of arc lamps, say six, working off a Brush dynamo, using Ayrton and Perry's ammeter and voltmeter.

In any part of the circuit we insert the ammeter, so that the whole of the current to be measured passes through it, as in Fig. 11. Remove the keeper, and turn the current on. The pointer immediately moves from zero to the right or left, as the case may be, and almost instantly, if the current is steady, comes to rest. In this instrument and also in the voltmeter the needle is deflected towards the terminal, at which the current enters. This of course means in the case of the voltmeter that the terminal, to which the needle points, is at a higher potential than the other. Thus in Fig. 11 the

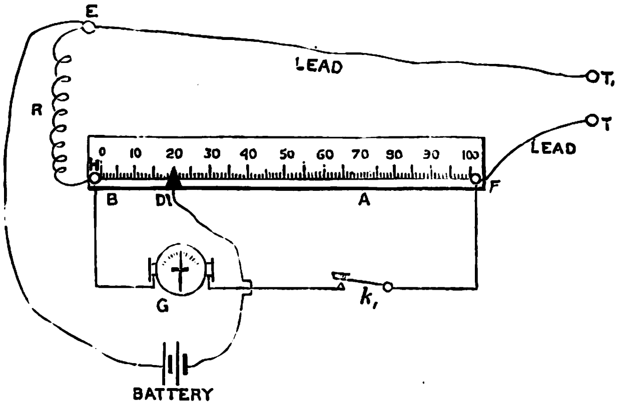

Fig. 11.

current is entering at the right-hand screw of both the ammeter and voltmeter, showing the current to be running in the direction of the arrows. The needle of the ammeter comes to rest in the present case at 7° on the scale. On referring to the table supplied with the instrument we find that 7° to the right means 10·1 amperes. If we now want to know the E.M.F. at the binding screws *t t* of any particular lamp we take the voltmeter and join its terminals to the said binding screws. This may be done with quite fine wire (20 to 22 B.W.G.), as only a very small current passes, and the resistance of the instrument is so high that two 10 feet lengths of No. 20 ($\frac{1}{5}$ ohm) make no appreciable difference. These wires from the voltmeter must be strongly and thoroughly insulated and great care taken not to short circuit the terminals of the instrument. On connecting the voltmeter to the lamp, as shown in Fig. 11, we obtain a deflection of 9·5°, which, according to the table, we find to mean 43 volts. The current remaining the same as we just found it, we have for this lamp

$$C = 10{\cdot}1 \text{ amperes,}$$
$$E = 43 \text{ volts.}$$

From these we know by Ohm's law that $R = \frac{E}{C} = 4{\cdot}36$ ohms. Again, these data will give us the electrical horse-power consumed in the lamp, for

$$\text{h.-p.} = \frac{CE}{746} = \frac{10{\cdot}1 \times 43}{746} = {\cdot}58 \text{ h.-p.}$$

In this way we can of course measure each of the other lamps L_2, L_3, &c.

Before measuring the E.M.F. at the terminals of the dynamo it is necessary to calculate roughly what it will be, for fear it may be too high for the voltmeter. There are six lamps in circuit, and we found the E.M.F. at the terminals of one of them to be 43 volts, so we may reckon on having about $43 \times 6 = 258$ volts or more at the dynamo terminals. The voltmeter we are using only reads up to 190 volts. We will make it less sensitive. Suppose the resistance of the instrument is 2,000 ohms; if in series with this we join a coil of 4,000 ohms we shall make the total resistance three times as great, consequently with the same E.M.F. we shall only get one third the current, and therefore one third the indication which we should with the voltmeter alone, so that the instrument is now one third as sensitive, and will consequently read up to $190 \times 3 = 570$ volts. If a coil cannot be obtained an exact multiple of the voltmeter resistance, any one of known resistance may be used, and the values found in the tables multiplied by $\frac{R + r}{R}$, where R is the resistance of the voltmeter and *r* that of the extra coil.

In the present case we want to reduce the sensitiveness to at least one half, $R = 2{,}000$, so *r* must be at least as much; adding a coil of 2,500 ohms we obtain a multiplying power of $\frac{2000 + 2500}{2000} = 2{\cdot}25$. On connecting the voltmeter with the coil of 2,500 ohms in series with it to the dynamo terminals we obtain a deflection of 25·5°, which the table gives as corresponding to 116·5 volts. Multiplying this by 2·25, we find the terminal E.M.F. of the dynamo to be 262 volts. If the true or total E.M.F. is required, for instance for tracing the characteristic curve of the dynamo, it is easily found from this. Suppose the internal resistance of the dynamo when warm has been previously taken and found to be 4·65 ohms. We have also $C = 10{\cdot}1$ amperes, terminal E.M.F. $= 262$ volts. To send a current of 10·1 amperes through 4·65 ohms requires (since $E = CR$) $10{\cdot}1 \times 4{\cdot}65 = 47$ volts, so that the total E.M.F. (at that point inside the dynamo where it is developed) is $262 + 47 = 309$ volts.*

The electrical horse-power expended in the dynamo (exclusive of mechanical friction†) is, as we saw above $\frac{CE}{746}$ horse-power,

$$\text{or since } (E = CR) = \frac{C^2 R}{746} = \frac{(10{\cdot}1)^2 \times 4{\cdot}65}{746} = {\cdot}634 \text{ horse-power,}$$

all of which is of course a dead loss, the total horse-power we have in the current, or "turned into electricity," as it is sometimes incorrectly expressed, being

$$\frac{309 \times 10{\cdot}1}{746} = 4{\cdot}18 \text{ horse-power,}$$

to obtain which, however, the engine may perhaps indicate some 6 or 7 horse-power in the cylinder.

(TO BE CONTINUED.)

AN ELECTRICAL TESTING ESTABLISHMENT.

As a rule a want has only to be put into words and made public in these days to be satisfied. There are many electricians and mechanics who have from time to time felt the want of a place where they could work out their ideas without fear of having the fruits of their labours indirectly pirated or directly filched from them—a place where the necessary tools, steam-power, testing apparatus, *et hoc genus omne*, would be at their disposal on moderate terms. Many, again, are able to perfect their work at home, but have no means of test-

* There is also a small (apparent) increase of resistance, when running, due to self-induction, which varies, for any particular machine, with the speed; so that the total E.M.F. would be slightly greater than that found above.

† Also of electrical friction in the form of Foucault currents, which are however reduced to a minimum in all well constructed dynamos.

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ing its performances or capabilities. A man may, for instance, make an incandescent or arc lamp, or build a dynamo, construct a battery or turn out a switch, but have no photometer, current meter, or other means of testing his productions. He may know of many places where the necessary apparatus is to be procured, but the price is too much for him, inventors as a rule having but little cash, and having already spent as much as they can afford in producing their apparatus in the rough. Or, again, there may be many works with which he is acquainted where the requisite testing instruments or machines are to be had, but he is shy of going to them from fear of his secret leaking out, a fear which, rightly or wrongly, strongly possesses inventors. What is wanted, then, is an establishment provided with every requisite for working and testing all kinds of electrical machinery and appliances, where an inventor may work out an idea *ab initio*, or where he may complete his rough model, test it thoroughly, and, if he desires, obtain an expert's report as to its capabilities. The idea of a place such as this has probably occurred to many before now, but the credit of making the idea public must be given to our contemporary, *The Engineer*. The want expressed has at once been met by an endeavour to supply it.

Mr. F. Geere Howard, of 36, Cleveland-street, W., has for some time past been using incandescent lamps to light a portion of his works, and has also devoted considerable time and attention to electrical engineering. Having plenty of steam-power, a workshop with every convenience in the shape of machine tools, and some light airy rooms at his disposal, Mr. Howard proposes to establish just such an electrical testing establishment as we have sketched above as being required. We recently paid a visit to his works, and may briefly state here what we saw. The major portion of the works is given up to furniture making, many machines driven by steam-power being used in the work. The engine used to drive these machines indicates 60 horse-power, which is considerably more than is required for use in the work, so that Mr. Howard can dispose of from 1 to 30 horse-power for driving dynamos, &c. The rooms which it is proposed to devote to electrical purposes are separated from the works, but shafting runs through to the dynamo room and tool shop, which is fitted with fast and loose pulleys, so that power is always available. There is also a Crossley Otto gas engine in the dynamo room always ready for use, but as it does not run very steadily Mr. Howard will replace it by a steam engine. At present there is only one dynamo in place, viz., a Siemens machine, giving 70 volts and 35 amperes, used to feed the incandescent lamps in the toolshop and test room. The former is immediately above the dynamo room, and is fitted with lathes, drilling and planing machines, all run by steam power, and every kind of hand tool. The incandescent lamps in this shop are so fitted above the different machines that they can be lowered or raised to suit the convenience of the worker. From the tool shop we pass into the test room, which is large, well-lighted, and airy. The lighting is effected both from the roof and the side, and it would be hard to find any room better suited for testing purposes. Here there are rows of secondary batteries, both the Elwell-Parker and the Crompton-FitzGerald, ready charged, so that any one wanting forty amperes, say, for half an hour, can have them. Here also are meters, variable resistances, incandescent lamps, switches, and other apparatus. We noticed amongst others Ayrton and Perry's volt and ampere meters, Crompton and Kapp's current and potential indicators, Siemens's dynamometer, &c. In a room below this is a powerful press, which might be used for secondary battery plates or for any purpose requiring great pressure. All of the above instruments and apparatus will be at the disposal of users of Mr. Howard's testing establishment.

For those who wish to carry out tests or experiments in the strictest privacy, Mr. Howard is fitting up two rooms on the other side of the works. One of these will be turned into a dark room for photometer work. Mr. Howard's idea is to run wires into these rooms, supply his customer with all the apparatus he requires, learn what current and E.M.F. he wants and for how long, and then, having fulfilled his wishes in this respect, leave him to lock himself in and carry out his experiments in as strict seclusion as the most suspicious of mortals could wish for.

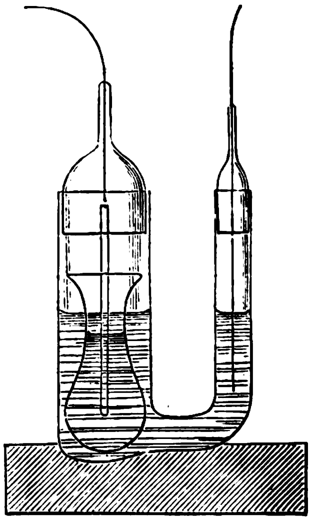
From what we saw during our visit there is no reason why Mr. Howard should not succeed most thoroughly in his endeavour, nor why his establishment should not develop a reputation in the electrical world similar to that enjoyed by Mr. Kirkaldy's famous testing works amongst engineers and ironfounders.

ON AN ELECTROSTATIC STANDARD OF POTENTIAL.*

BY MM. CROVA AND GARBE.

Having had occasion to make continuous use of Thomson's quadrant electrometer (Mascart's model), we have been struck by the variations, often considerable, of the potential of the charging battery, formed, as is known, of small zinc-platinum elements and pure water, variations which are partially corrected by frequent testing (*étalonnage*) of the electrometer, by means of a Daniell cell taken as a standard. We have assured ourselves, by preliminary experiments, that these variations are due to two principal causes.

The first is defective insulation of the elements. It is a fact that, though often satisfactory at first starting, the insulation gradually deteriorates, by reason of the damp which condenses on the external surface of the elements and their support, and by the deposit of dust, which causes a varying short circuit, the effect of which is to diminish the difference of potential at the two poles.



MM. Crova and Garbe's Cell.

The second is the polarisation of the platinum in the water element, a consequence of the short circuiting we have just mentioned, and of that which may be produced accidentally in the handling of the electrometer, when one of the poles of the battery is connected, if only for an instant, with earth. The weakness which results is such that a sensibly long rest is requisite for the battery to regain approximately its initial potential.

The electrometric determinations attained on the other hand a great degree of regularity when we used our own charging elements. We proposed to obtain elements with a constant potential under rigorously defined and easily realisable conditions, by rendering their insulation perfect, and by preventing diffusion of the liquids and polarisation; it is true that, under these conditions, the internal resistance of the elements is enormous, but this fact also renders them very constant, even when they are short circuited for a very long time. We have kept elements insulated for three months; at the end of this time their potential had not varied, and there was not a trace of alteration of any kind. Each element is composed of a glass tube, as shown in the illustration. It has a lateral tube soldered to its lower part, and the two openings are closed by

* Translated from the *Journal de Physique* for July.

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hollow glass stoppers, as shown; the conductors are fused into the thin end of the stoppers. Finally the tube is fixed on a small ebonite support, and is varnished with gum lac over the whole of its outer surface. To form one Daniell element we put into the two connecting tubes a solution of pure sulphate of copper previously saturated at the temperature of zero, then decanted and preserved for use. A small glass tube whitened with a basis of potash (in order to render it more hygrometric), with its lower end closed, is filled with a solution of pure sulphate of zinc, also saturated at the temperature of zero, and placed in the axis of the large tube in which it is fixed, by means of conveniently formed swellings, which hold it in place.

A copper wire fused into the stopper of the small tube dipping into the sulphate of copper, and an amalgamated zinc wire soldered to a platinum wire fused into the stopper of the large tube, dipping into the sulphate of zinc, comprise the poles of the cell. The level of the liquids is below the opening of the sulphate of zinc tube; thus mixing of the liquids is impossible, and electric communication is established by the layer of water condensed on the surface of the sulphate of zinc tube. (A cell which resembles ours in this last point has been proposed by M. O. Lodge, *Phil. Mag.*, Vol. V., p. 1, 1878, but the conditions of comparison, and above all insulation, seem to us far superior in the cell we have constructed.) It is a good plan to heat this tube to a red heat to destroy all traces of greasy matter on its surface before filling it, and not to handle it afterwards, except with metal pincers previously heated. The use of these cells as a standard leaves nothing to be desired. If the charging battery is constant, the same number will always be found on the divided scale as the value of the Daniell cell, even when the cell has been left for several hours on short circuit. We have not been able to measure its internal resistance; for, on introducing between the poles a resistance of 7,000 ohms, we could not detect any appreciable difference of potential between them in the electrometer; we could not succeed in obtaining the smallest deflection on a galvanometer, nor the slightest noise in a telephone. This great internal resistance necessitates good insulation of the poles, for the least derivation by surface conductivity would produce a notable decrease of potential; for this reason we have so made the cell as to place the greatest possible distance between the poles. The varnish of gum lac renders the insulation perfect, as we have assured ourselves.

We have modified the construction of this element in order to render it less liable to accident when being carried about. Our plan is to replace the two liquids by powdered pumice stone, calcined at a red heat with sulphuric acid, then saturated with the two solutions. The potential is the same whether use is made of the liquid or pumice stone battery, or even of one Daniell element with a porous jar charged with the same two solutions, before diffusion has modified their composition. These elements can therefore be employed either as a standard or as a charging battery; in the latter case they are arranged in a closed box, and rigid conductors pass without touching them in the axis of the two ebonite tubes fixed in one of the sides. Instead of Daniell elements bichromate elements constructed in the same manner (zinc, sulphate of zinc, bichromate acidulated with 1-10th of sulphuric acid, platinum) may be used as charging batteries, the liquids being consolidated by pumice, as we have already described. These elements give about two volts, and do not change after having been on short circuit for several hours. By measuring the difference of potential at the two poles, between which we interposed a considerable resistance, we have been able to measure in certain cases their internal resistance, which was about 100,000 ohms, and we have been able to hear slight noises in a telephone; but these results are very variable. The potential alone does not vary.

The standard of electromotive force can thus be readily obtained, either in a lasting manner, for electrostatic measurements, with the batteries we have just described, or in passing, for electro-dynamic measurements, with the same liquids separated by a porous jar, taking care, in the latter case, to renew the liquids, which are perfectly defined at each determination. For greater exactitude the element should be kept at zero, or, if working at the ordinary temperature, its electromotive force should be corrected by the coefficient, not very great, by the way, of variation with temperature. The various numerical determinations will form the subject of a later communication.

MEASURING THE CAPACITY OF A CONDENSER AND DETERMINING THE PERIOD OF A TUNING FORK.*

BY R. T. GLAZEBROOK, F.R.S.

The experiments described in the following paper were undertaken at the request of Messrs. Latimer Clark, Muirhead, and Co., for the purpose of testing one of their condensers "which," quoting from a letter from the firm, "has lately been made and which we use in the factory. In its construction it is the same as all our condensers, and is made of sheets of mica and tinfoil, and laid with paraffin wax."

The method employed was a modification of one given by Maxwell (Vol. II., sec. 776), and used by J. J. Thomson (*Phil. Trans.* III., 1883) in his recent determination. The following is his description of the arrangement:—

"In a Wheatstone bridge, A B C D (Fig. 1), with the galvanometer at G and the battery between A and B, the circuit B D is not closed, but the points B and D are connected with two poles, R and S, of a commutator, between which a travelling piece, P, moves backwards and forwards. P is connected with one plate of a condenser, the other plate of which is connected with D. Thus, when P is in contact with S the condenser will be charged, and until it is fully charged electricity will flow into it from the battery; this will produce a

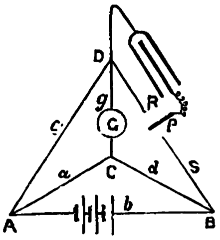

FIG. 1.

momentary current through the various arms of the bridge. When the moving piece P is in contact with R the two plates of the condenser are connected, and the condenser will discharge itself through D R; and as the resistance of D R is infinitesimal in comparison with the resistance in any other circuit, the discharge of the condenser will not send an appreciable amount of electricity through the galvanometer. Thus, if we make the moving piece P oscillate quickly from R to S, there will, owing to the flow of electricity to the condenser, be a succession of momentary currents through the galvanometer. The resistances are so adjusted that the deflection of the galvanometer produced by these momentary currents is balanced by the deflection due to the steady current, and the resultant deflection is zero. When this is the case, there is a relation between the capacity of the condenser, the number of times the condenser is charged and discharged in a second, and the resistances in the various arms of the bridge."

The investigation given by Maxwell is only approximate; we shall quote, therefore, the result given in Thomson's paper.

Let a be the resistance of A C,
b „ „ A B,
c „ „ A D,
d „ „ B C,
g „ „ D C.

Let C be the capacity of the condenser, n the number of times it is charged and discharged per second; then

$$nC = \frac{a\left\{1 - \frac{a^2}{(a+c+g)(a+b+d)}\right\}}{cd\left\{1+\frac{ab}{c(a+b+d)}\right\}\left\{1+\frac{ag}{d(a+c+g)}\right\}}.$$

* *Phil. Mag.* for August.

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The commutator was the one used by J. J. Thomson, and we quote his description :—" The current from some Grove cells passes first through a tuning-fork interrupter and then through the coils L M (Fig. 2) of an electro-magnet. P N is a strip of brass with a piece of iron wire attached to it. When there is no current passing through the electro-magnet, the elasticity of the rod P N makes it press against the screw T, which is electrically connected with the binding-screw R. When the current passes through the electro-magnet the magnet attracts the iron attached to the rod P N, and brings it into connection with the stop G, which is electrically connected with the binding-screw S. The letters P R S indicate the same points in this figure as in Fig. 1. All the places where contact is made are covered with platinum, and the whole arrangement is fastened down to an ebonite board. As the current passes intermittently through the coils L M of the electro-magnet, the vibrating-piece P N strikes alternately against the parts G and T. When it strikes against G, the opposite plates of the condenser are connected with the two poles of the battery; when it strikes against T the condenser is discharged."

The main advantages of this method over the one ordinarily employed for the determination of the capacity of a condenser whose capacity is comparable with a microfarad are easily seen. In the first place it is a null method; no assumptions are required as to the constancy of the battery. In the second, the galvanometer can readily be made much more sensitive. For accurate work in the ordinary method, the field of force in which the galvanometer-needle hangs should be nearly uniform. The earth's force is much too strong, unless an enormous battery-power be employed, and it is difficult to secure a uniform field by a control magnet. Something may, of course,

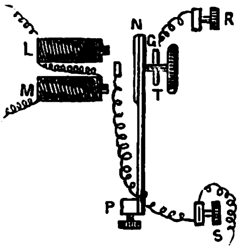

Fig. 2.

be done by the use of an astatic galvanometer-needle; but it is impossible to increase the sensitiveness in this way very much, because the torsion of the suspending fibre then becomes important. Again, in the ordinary method, the time of swing cannot be determined accurately if it be made too small; the moment of inertia of the suspended parts therefore must be considerable, and the deflection produced by a given quantity of electricity suddenly discharged through the galvanometer is proportionately decreased; for, if T be the time of swing, θ the throw produced by a quantity of electricity Q, then T sin $\frac{1}{2}\theta$ is proportional to Q. In addition to this, there is the correction for damping which has to be considered.

On the other hand, objections may be raised to the method which has just been described. The most important of these is founded on the fact that the time during which the plates of the condenser are in contact either with each other or with the poles of the battery is very short. It may happen, then, that the condenser is neither charged nor discharged completely at each vibration of the commutator; while if there be any electrical absorption in the condenser, its effects will depend on the time during which the contact lasts. The experiments to be described were undertaken with the view of testing the method for these defects. The time during which the plates of the condensers are connected with the battery is the time during which the spring P N is in contact with G. This is only a fraction of the period of the tuning-fork which governs the commutator, a fraction which depends on the distance between the end of the screw T and the point G, and on the strength of the current in the electro-magnet.

A series of experiments were made to test the effect of varying the position of the screw T, keeping the battery the same. In these, four Leclanché cells were used in the battery-circuit A B, and two pint Groves to drive the commutator. The position of the spot of light on the scale was noted, and then the value of the resistance d adjusted until no deflection was produced when the galvanometer-circuit was closed by means of a key.

The commutator, when working correctly, emitted a definite sound which was readily recognised, and it was found that the screw T could be adjusted within certain limits without altering this sound.

Table I. gives the results of these observations.

Table I.

Commutator Adjustments.	Value d in B.A. units.
Screw T set	905
Screw T readjusted, note good	906
" " " "	906
" " " bad	906
" " " good	906
Screw T loosened one turn. Spot off scale.	
Screw T readjusted, note good	906

Thus the value of d required to give a balance is practically the same throughout, and the commutator with a definite battery power can readily be set to give a definite result; moreover, a balance could never be obtained except with the resistance 905 or 906. In the fourth observation the note of the commutator was marked as bad; but the spot remained stationary, showing that though there seemed to be a slight irregularity in the sound, it was too small to affect the balance. The sensitiveness was such that an alteration in d of 1 B.A. unit produced a deflection of from two to three scale divisions. The number of vibrations of the fork was about 32 per second.

Another set of observations was then taken to test the effect of varying the battery power driving the commutator, thus altering the force with which the spring P N is attracted to G, three Grove cells being used in place of two. The values of d found in two separate observations were 905·5 and 905.

Observations were made to test the effect of varying the period of the driving fork. Forks of frequencies of approximately 16, 32, 64, and 128 to the second were taken, and the pitch of the lowest of these determined absolutely by comparison with the clock in the method described by Lord Rayleigh (*Nature*, XVII., p. 12; *Phil. Trans.*, 1883, Part I.). This fork and the 32 fork were then set going on independent circuits, and a pointer attached to the 32 fork was watched over the top of a plate of thin metal which had been all along fixed on to the 16 fork, the eye being placed so that this pointer was visible for only one position of the 16 fork in each vibration. In this way the beats between the octave of the 16 fork and the 32 fork were visible, and could easily be counted.

Thus the period of the 32 fork was found, and then in a similar manner those of the 64 and 128 forks. By loading with wax one of the two forks under comparison it was easy to find which of the two was gaining.

Each of these forks was used in turn to drive the commutator, and the value of the capacity calculated from the observations. The values of the resistances were as follow:—

a was a standard coil of 10 B.A. units, d a resistance of 1,000 B.A. units, taken from a box by Messrs. Elliott Bros., and c a variable resistance from another box by the same firm.

g, the galvanometer resistance, was about 11,000 B.A. units; and b, the battery resistance, from 5 to 6 B.A. units. The galvanometer resistance was higher than necessary, but it was for other reasons the most convenient instrument for the purpose. The value of c varied from about 1,800 to about 240 B.A. units.

It will be found that, with these values, the equation giving the capacity may be written

$$nC = \frac{a}{cd\left\{1 + \frac{a}{d\left(1+\frac{c}{g}\right)}\right\}}$$

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[The approximate equation given in Maxwell is

$$nC = \frac{a}{cd}.]$$

We shall use N_{16}, &c., to denote the frequency of the fork of approximate frequency 16.

The following are the results of the observations :—

(1) Fork 16 used.

Fork compared with pendulum. Fork loses 1 vibration in 7·46 seconds.

$$N_{16} = 15{\cdot}866 \text{ sec.}$$

Resistance observation :—

$$a=10;\ d=1000;\ c=\left\{\begin{matrix}1895\\1892\\1893\end{matrix}\right\}1893 \text{ mean.}$$

Sensitiveness 1 scale-division for alteration of 1 B.A. unit in c.

From these we find

$$C_{16} = {\cdot}3300 \frac{\text{ohm}}{\text{B.A. unit}} \text{ microfarad.}$$

(2) Fork 32 used.

16 beats occur in 42 seconds between octave of 16 and 32. Fork 32 gaining.

$$N_{32} = 32{\cdot}11.$$

Resistance observations :—

$$a=10;\ d=1000;\ c=\left\{\begin{matrix}934\\934\\934\end{matrix}\right\}934 \text{ mean.}$$

Hence

$$C_{32} = {\cdot}3304 \frac{\text{ohm}}{\text{B.A. unit}} \text{ microfarad.}$$

(3) Fork 64 used.

10 beats occur between 64 and octave of 32 in 50 seconds. Fork 64 gaining.

$$N_{64} = 64{\cdot}42.$$

Resistance observations :—

(α) $a=10;\ d=1000;\ c=466;$

$$C_{64} = {\cdot}3299 \frac{\text{ohm}}{\text{B.A. unit}} \text{ microfarad.}$$

(β) $a=10;\ c=1000;\ d=\left\{\begin{matrix}461\\461{\cdot}5\end{matrix}\right\}461{\cdot}3 \text{ mean.}$

$$N_{64} = {\cdot}3299 \frac{\text{ohm}}{\text{B.A. unit}} \text{ microfarad.}$$

(4) Fork 128 used.

16 beats occur between the 128 fork and octave of 64 fork in 26·25 seconds. Fork 128 gaining.

$$N_{128} = 129{\cdot}05.$$

Resistance observations :—

$$a=10;\ d=1000;\ c=232{\cdot}5.$$

Hence

$$C_{128} = {\cdot}3301 \frac{\text{ohm}}{\text{B.A. unit}} \text{ microfarad.}$$

The sensitiveness throughout these observations was such that an alteration of 1 in 2,000 in the resistance produced a deflection of about one scale-division in the spot of light.

Hence the greatest difference in the observations amounts to about 5 in 3,300, or about 1 in 660 ; and there is no trace visible of variation in the capacity with the time of charging.

We will collect the numbers together :—

C_{16}	·3300
C_{32}	·3304
C_{64}	·3299
C_{64} (second arrangement)	·3299
C_{128}	·3301

$$\text{Mean value of capacity} = {\cdot}33006 \frac{\text{ohm}}{\text{B.A.U.}} \text{ microfarad.}$$

Taking the Cavendish-Laboratory experiments we have

$$1 \text{ B.A.U.} = {\cdot}9867 \text{ ohm.}$$

$$\therefore\ C = \frac{{\cdot}33006}{{\cdot}9867} \text{ microfarad.}$$

$$= {\cdot}3344 \text{ microfarad.}$$

If we take the legal ohm and the value of the specific resistance of mercury in B.A. units, adopted by the B.A. Committee,

$$1 \text{ B.A. unit} = {\cdot}9889 \text{ ohm,}$$

and $C = {\cdot}3336$ microfarad.

This value supposes that the various coils used have their nominal resistance in B.A. units. And this assumption is correct, at any rate to 1 in 1,000. Thus it seems that the method gives satisfactory results, and may safely be used to determine the capacity of a condenser.

But the converse of the method may be even more useful. The fundamental equation gives us C if we know n and the resistances ; it will equally give us n if we know C and the resistances ; and in many cases this may be the readiest method of finding n, especially if the period is too long to give an audible note. Thus in the above experiments I require to adjust a fork to vibrate about 16 times a second, the lowest I could obtain being one of a frequency of almost 20.

I made observations with the 32 fork, the pitch of which was marked on it by the maker, of the value of c required to produce a balance, then doubled this value of c, and set the fork which it was required to adjust to drive the commutator. Leaden weights were then fixed with screws on to the prongs of the fork, and their position was adjusted until the galvanometer balance was not disturbed on making contact. It was clear, then, from the approximate formula that the frequency of the fork was very nearly 16. And on making the comparison with the clock, it was found to be 15·866, as already stated.

My thanks are due to Messrs. Wilberforce, Whitehead, and Fitzpatrick for assistance in making the experiments.

CORRESPONDENCE.

DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : I have noticed the papers and discussions that have appeared from time to time in *The Electrician*, and have experienced some disappointment from the paucity of the various writers. It appears to me that a valuable paper like "ours" ought to contain something more than a repetition week after week of the "construction of dynamos" under various headings when the main part of the subject is left entirely out. If some of the contributors to this journal would go deeper into the subject and give some formula by which the resistances of the armature and field-magnets might be worked out from—*i.e.*, the proportions which should exist between them, so that the most work could be got out of the machine, and also a formula by which the amount of wire necessary for a shunt machine might be calculated, they would be doing a great many of your readers much valuable service. Hoping some one of the writers will take this matter up, yours, &c., G. S.

EDUCATIONAL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : Could any of the readers of *The Electrician* inform me whether there is any institute in or near London, S.E., where I can obtain the necessary coaching for the assistant examiners', patent office, civil service examination ?—Yours, &c.,

LUX.

THE GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company for July were £26,360; for the period from 1st January to 31st July they were £155,880, against £145,659 for the corresponding months of 1883, and £137,965 for the same period of 1882.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes 289
The Elements of Electric Light Engineering. By E. C. Rimington. (Continued.) Illustrated 294
An Electrical Testing Establishment 295
On an Electrostatic Standard of Potential. Illustrated ... 296
Measuring the Capacity of a Condenser, &c. By R. T. Glazebrook. Illustrated ... 297
Correspondence 299
The Telegraph and Colonial Federation 300
The Health Exhibition.—V. Illustrated 301
Dynamo-Electric Generators. (Continued.) Illustrated ... 304
International Inventions Exhibition, 1885 305
Experiments on the Efficiency of Incandescent Electric Lamps. By H. B. Gale. (Continued.) Illustrated ... 305
Legal 307
Companies' Meetings—
The Anglo-American Telegraph Company 308
The Submarine Telegraph Company 310
Eastbourne Electric Light Company 311
National Telephone Company 312
Cuba Submarine Telegraph Company 312
Companies' Share List 312
Traffic Receipts 312

THE TELEGRAPH AND COLONIAL FEDERATION.

When last we had occasion to refer to the part played by the telegraph in the international game of politics, Prince Bismarck had just been anathematising those swift winged messengers which have made the labours of his declining years almost too much for him to bear. What would have been his frame of mind had Germany possessed a colonial empire it is needless to conjecture. The methods of an irresponsible and irremovable Minister are not our methods, and probably we never shall enjoy the experience of a ruler whose eye must be watchful everywhere, and whose hand must exert control over everything. Nevertheless, even to English statesmen the telegraph is attended with inconveniences, which we have dwelt upon more than once in these pages, not the least of which is the loss of responsibility in our agents abroad. The race of men of whom the late Sir Bartle Frere was an illustrious example is becoming extinct, and in the presence of the telegraph can never again be revived. Our Pro-Consuls abroad have almost ceased to act on their own authority, and are steadily accustoming themselves to the habit of working, if not with a rope, with a wire round their necks. That the British Empire is no longer a school in which uncrowned kings can be educated may be a matter for sentimental regret, but it is a fact, and a fact which has to be faced whether we like it or not. The burden of empire which was formerly distributed over the shoulders of its representatives abroad has now to be borne by responsible Ministers at home. The titular dignities remain, and will probably long survive, but their functions are now curtailed to dimensions which grow rapidly smaller and smaller.

This we say is the irrevocable fact; and it has been created mainly, indeed almost solely, by the telegraph. How great has been the revolution effected through this instrumentality was well illustrated the other day at the Westminster Palace Hotel, where a number of statesmen, representing various shades of political thought, met together to inaugurate a movement for the confederation of our Colonial Empire. Into the merits of this project it is not our province to enter, but we are justified in pointing to the causes which have rendered the idea a feasible one. So recently as ten years ago, or even later, not only would it have been pronounced a dream, but a very foolish and mischievous dream. There were public men then who openly advocated disintegration. It is disputed that a certain professor ever uttered the phrase "Perish India," but the fact of its now being denied is highly significant. At all events there were men, and plenty of them, who virtually said as much concerning the bonds that united the British colonies to their mother country. These political philosophers were of home growth, it is true; the colonies never produced any such that we know of. But where are they now? They have probably not changed their minds, but they are silent; and we venture to assert that it is the telegraph that has proved stronger than their convictions. While they were brooding over their theories of colonial independence, which nobody desired to put into practice, but which might have developed, as theories are apt to do, into decisive action, the telegraph has been welding us closer and closer with our distant brethren, and making separation almost a physical impossibility even if we wished it ever so. Commenting on this Federation scheme one of the daily papers had the unheard of temerity to say that a great deal of good would have accrued to the human race had the English Colonists who founded the United States remained true to the English crown. The utterance is chiefly remarkable as showing what a radical change has come over public opinion in recent years; but it may be added that had the telegraph existed then the War of Independence would never have occurred. Irresponsible vice-royalty has its drawbacks, and the arbitrament of war is one of them. The telegraph is a great peacemaker, and it may be confidently asserted that if ever the colonies give themselves over to the teaching of the philosophical disintegrationists, their final message will be peacefully transmitted per cablegram, not at sword's point. But that message is never likely to arrive, for every increase of facility for interchange of views renders misunderstanding less easy and conflict more improbable. It has been truly said that most wars have arisen through misunderstanding; we should prefer to say through practical difficulties in the way of coming to an understanding. The telegraph removes one chief difficulty by bridging time and space, and averting the consequences of impatience and angry impulse which distance and blank separation are liable to intensify.

We have nothing to do with the rival methods of confederation which will form a subject of debate for some time to

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come; but we are safe in assuming that confederation of some kind is demanded, and will ultimately be in operation. Without the telegraph this could not have been; if government by proxy is no longer permissible, government by telegraph is the only alternative, and it is a thoroughly practicable one. Steam-power has rendered our remotest colony almost as near in point of time as were the north of Scotland and Ireland in the days of mail coaches and fast-sailing cutters. The telegraph has done more than this, for it has brought even the most distant points virtually within earshot of each other. With the exception, perhaps, of the Mauritius, there is hardly an English colony or naval station of any importance that is not now in practically direct communication with Downing-street by means of at least one, and often by two or three cable routes under the seas. Commercial enterprise has led to this great innovation, and probably commercial considerations will ultimately determine the form which Colonial Federation shall take, for it is as true that trade follows the flag as that cable laying carries it. But be that as it may, the movement now set on foot for forming a United States of the British Empire is one that only the telegraph could have brought within the range of practical politics. The inconvenience complained of during the period of transition through which we are now passing, when the telegraph is voted a nuisance and an encumbrance, is only temporary, and will entirely disappear when the final stage of permanency has been reached.

HEALTH EXHIBITION.—V.

We have seen that in electric lighting, as in gas lighting, there are three important parts of the system to consider, the prime motor—be it a steam engine, gas engine, water wheel, turbine, or any other source—the generator of the electricity, and the burner. In gas lighting we find retorts, gasometers, and burners, the gasometer being connected to the burners by pipes, while in electric lighting the generator is connected to the lamps by means of wire.

Suppose this is our first visit to the Healtheries, and we enter during the day to stroll round, see the various exhibits, not forgetting that great centre of admiration, Old London. Passing through the representation of Old London, one of its passages leads us into the electrical machine room, or we may reach this department by a more direct way from the main entrance. There is nothing very prepossessing in this room in the day time, few people are to be seen, and those seen are busily engaged among the machinery. A glance shows a wilderness of wheels and belting, huge boilers in front of us, large engines to the right and left, with dynamos sprinkled about like accents in a page of Greek. The maze at Hampton Court you will think a simple puzzle to that of finding a clue to this maze of machinery, and yet, under the superintendence of Mr. Gooch, the engineer, it is arranged in due order, and so that every foot of space is utilised to advantage.

The whole of the motive power to drive the electric light machinery has been supplied by the well-known firm of Messrs. DAVEY, PAXMAN and Co., of Colchester. The power required to drive this machinery amounts in the aggregate to no less than from 1,300 to 1,500 horse-power. This power is given off by six large engines, which obtain the necessary steam from eleven boilers, the whole offering to the visitor a fine display of first class machinery. Entering from the hall we notice six boilers standing together facing the passage which is parallel with the south gallery. Each of these, we are informed, is 40 horse-power nominal, *i.e.*, they will, when fired with good Welsh coal, easily generate steam of 80-100lb. pressure per square inch. This steam is used for supplying the two pairs of coupled engines, which are together giving off when running each evening about 700 indicated horse-power, or power enough to lift about 10,000 tons one foot high in one minute. These engines each consist of two horizontal fixed engines coupled together and give off the power from fly-wheels fixed on the crankshaft between them. The cylinders of the right-hand engine are 19in. in diameter, with 32in. stroke. The two fly-wheels are each 12ft. in diameter, weighing collectively about 8½ tons. These fly-wheels take 15in. belts. The left-hand engine has cylinders of 18½in. diameter, 32in. stroke, with one fly-wheel of 12ft. diameter, weighing about 5¼ tons. This wheel takes a 24in. belt. Both engines are mounted upon strong, massive, cast-iron girder frames, and are in all respects meeting the requirements of the electric light. The utmost regularity of speed is obtained, and great economy in fuel, for which indeed these and all other engines exhibited by Davey, Paxman and Co. are noted. This is to a great extent due to the excellent way in which the adjustable governor in combination with the patent automatic expansion gear controls the engine, admitting at each stroke of the piston only the exact quantity of steam necessary to do the work. In order to illustrate the working of the governor and the expansion gear we will assume that the driving band of the left-hand coupled engine suddenly broke when the engine was transmitting about 300 horse-power and running at its normal speed of about 72 revolutions per minute. The natural inclination of the engine, having now no work beyond its own friction to do, would be to run considerably quicker, but as soon as the engine speed increases, the speed of the governor also increases, and the centrifugal force causes the balls to rise higher. This movement is transmitted to a link, which in being lifted shortens the travel of the expansion valve so as to admit only steam enough to the cylinder to keep the engine running at its normal speed. It may not be uninteresting to know that the driving belt of the left-hand engine a few weeks ago actually did break under exactly such circumstances as above assumed, and that the engine in less than one revolution resumed its normal speed of 72 revolutions per minute. We should imagine that this is almost unique in the history of steam engines. About 320 out of the 1,300 indicated horse-power necessary to drive the electric light machinery at the Health Exhibition is supplied by two compound engines of different types. One is a horizontal fixed engine with cylinders of respectively 15 and 22½in. diameter provided with steam from two steel boilers of the locomotive type, and the other is a so-called semi-fixed engine with cylinders of respectively 12¼ and 20in. diameter. This engine is mounted underneath the boiler. The stroke of both engines is 24in., and the piston speed about 400ft. per minute. Without entering into any elaborate explanation of all the benefits derived by using a compound engine in preference to an ordinary non-condensing engine we may just mention that whilst in the ordinary non-condensing engine the steam, after having done its work, is exhausted into the air at a pressure considerably above the atmospheric pressure, the steam, after having done work in the small cylinder of a compound engine, is exhausted into a larger cylinder, in which it is allowed to expand until it is exhausted into the air at a pressure of about the atmosphere itself. Consequently the loss of steam which takes place in the ordinary non-condensing engine is avoided in the compound engine. Hence the great saving of fuel and always increasing demand for this class of engines, especially for electric light purposes. The next two engines exhibited by Messrs. Davey, Paxman and Co. are both double-cylinder engines, one a semi-portable engine, *i.e.*, with engine on top of the boiler, and the other of the semi-fixed type, with the engine underneath the boiler, and mounted upon a strong wrought-iron frame. The semi-portable engine has cylinders of 10½in. diameter and 14in. stroke, and will indicate about 80 horse-power, with 80lb. pressure of steam per square inch. The semi-fixed engine has cylinders of 12in. diameter, 14in. stroke, and will indicate about 100 horse-power, with 80lb. pressure. As before mentioned, all the engines are fitted with the improved adjustable governor and the patent automatic expansion gear. Passing from mere description to simple criticism, it seems to us that Messrs. Davey, Paxman, and Co. are devoting a considerable amount of attention to specially adapt engines to the require-

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ments of electric lighting, and in the long run they will meet with all the success they desire as well as merit. The electric light may be under a shade just now—not at the Healtheries—but its time will come, and then those who have studied its requirements should reap their reward. It might be mentioned here that the shafting is carried in high pedestal bearings, supplied by Mr. Mumford, of Colchester. The engines are supplied with Schonheyder's sight-feed impermeators, in fact in no one respect has anything connected with the motive power been left to chance, but every detail has been carefully considered, with the result that night after night the running of the machinery is carried on without a hitch.

Turning from the engines we will look round at some other exhibits:—

The Edison and Swan Company's installation of incandescent lamps at the Health Exhibition is one of the largest and finest displays of electric lighting yet witnessed in England. It comprises about 1,000 incandescent lamps, of which rather more than one half are Edison lamps, and the rest Swan lamps, distributed as shown in the plan, Fig. 1, from which it will be seen that all the lamps are placed at a considerable distance from the machine room. They are all situated in one direction as regards the machines, and are all on the same circuit, so that visitors to the Exhibition are able to judge what sort of thing an electric light cable to convey current for 1,000 lamps actually is. In addition to the lamps installed by the company themselves, a large number of Swan lamps are used by other exhibitors, making the total of Swan lamps in the Exhibition between 3,000 and 4,000.

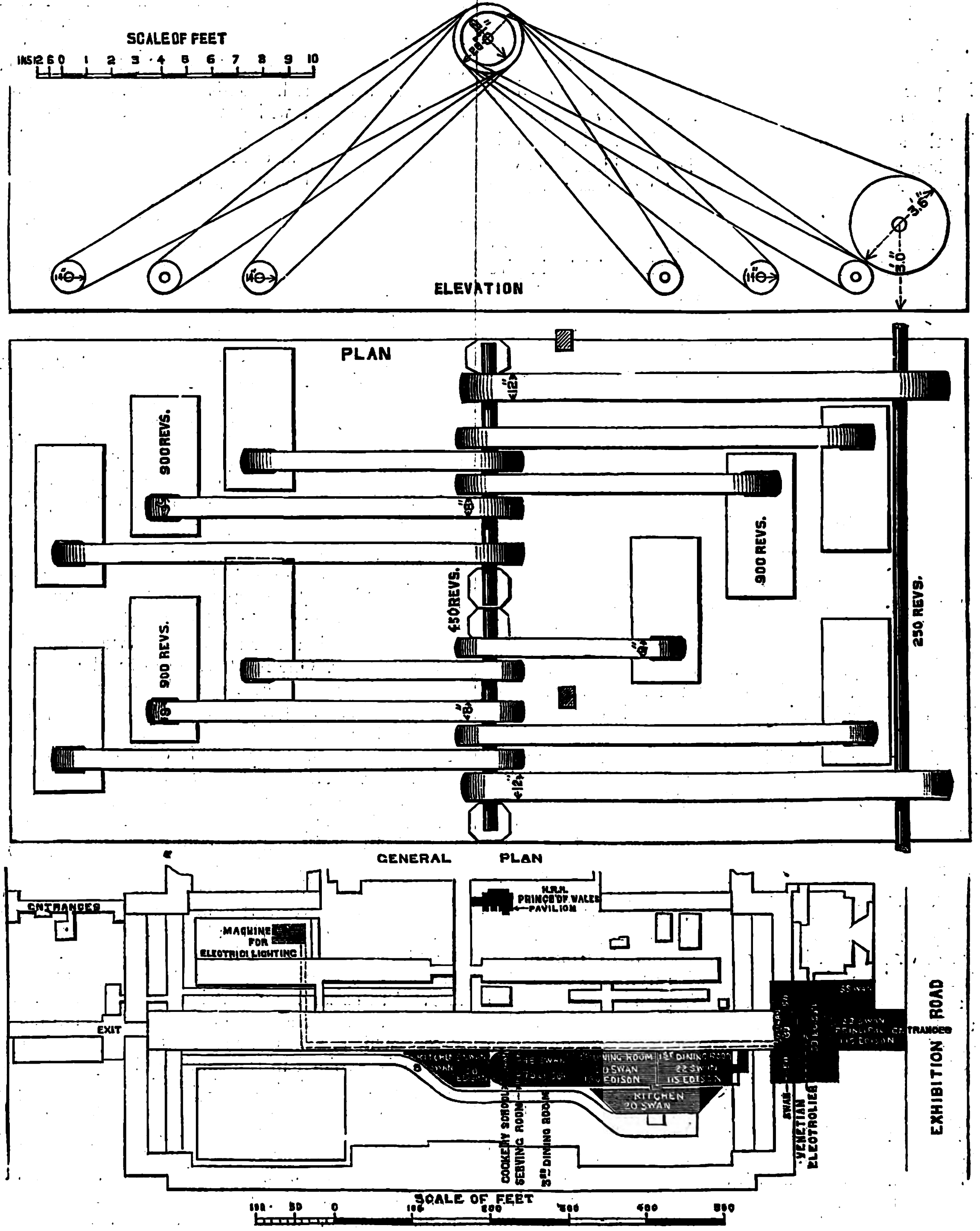

Fig. 1.—Arrangement: Plan and Elevation of Edison Dynamos; Plan of Distribution of Lamps.

For the first 150 feet from the dynamos Edison electric tubing, with an area of 1·054576 square inches of copper, surrounded by insulating compound, and encased in cast-iron pipes, has been employed, each cable being in a separate pipe; for the remainder of the distance—that is, about 650 feet—a

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similar Edison tubing, but with an area of ·776826 square inches of copper, has been used. The accompanying Figs. 2 and 3 show sections of the two sizes of tubing. The branch cables and wires are all heavily insulated with india rubber, tape, &c., and are all mechanically separated in the manner invariably adopted by the Edison and Swan Company.

The relative resistance of the main and sub-main cables, which measure about ·02 of an ohm, to that of the lamps has been calculated to allow of a fall of potential between the machines and lamps of about 12 per cent., assuming the working load to be not less than 1,000 lamps, all situated at the end of cable.

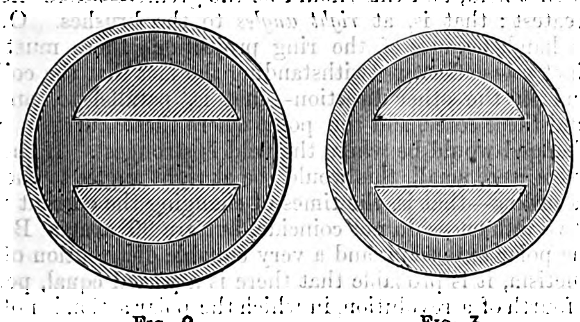

FIG. 2. FIG. 3.

At a distance of 530ft. from the dynamos, a branch cable is taken off for supplying the dining rooms and kitchen, and the cables for supplying the vestibule and the entrance hall are taken off at a distance of 800ft., which may be considered the end of the main cables. It will thus be seen that the main cable forms a loop, of which the total length is nearly a third of a mile, its section being such that at no point with a full load will the current passing through it ever exceed 1,000 amperes per square inch of copper. The lamps, with hardly any exception, are all high-resistance lamps, requiring an

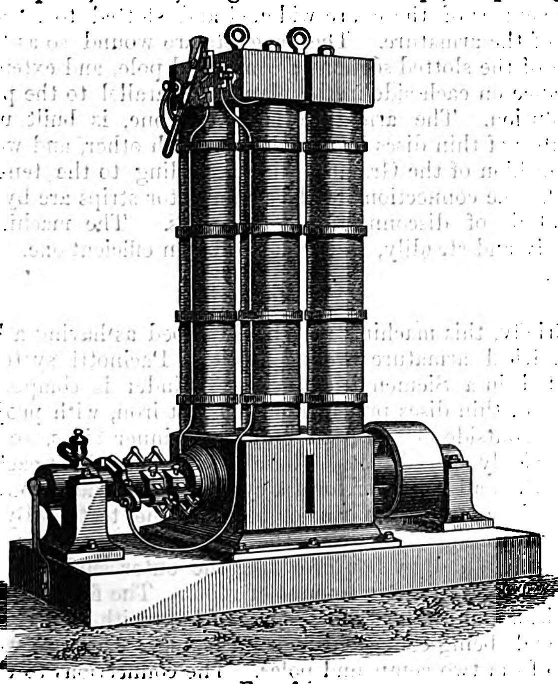

FIG. 4.

electromotive force of 90 volts, those of the Edison type consuming about ·75, and those of the Swan about ·7 ampere each, giving respectively a light equivalent to 16 and 20 candles.

The dynamos, ten in number, are of the Edison L type (Fig. 4), each capable of sustaining 150 lamps, the speed being calculated at 950 revolutions per minute, which will allow a useful margin in case of reduction in speed owing to accidents or other causes. These machines have been used as being the most readily available; but a newer type of dynamo is now (Wednesday) being erected to substitute in place of some of them. Two separate counter-shafts driven off the main counter-shaft have been fixed, each one driving five machines. Each set of five is arranged to be stopped or started, one by means of an Addyman friction clutch, and the other by striking the belt on to a loose pulley. The entire ten machines are connected in parallel circuit to the main cables, and each of the ten can be controlled entirely at will both as regards the field and the main-circuits. The field circuits of all the dynamos are in multiple arc between the mains, in two groups of five

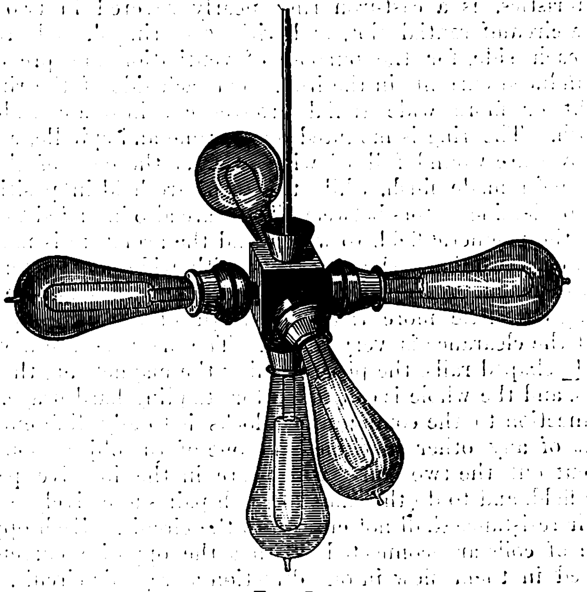

FIG. 5.

each, each sub-division being controlled by a variable resistance thrown in at pleasure. The total field-resistance is two ohms, and the total field-exciting current is about 50 amperes. By this method of throwing in a variable resistance the electromotive force will be so governed as to maintain a constant potential of about 90 volts at the furthest end of the main cables, the electromotive force at the machines being prob-

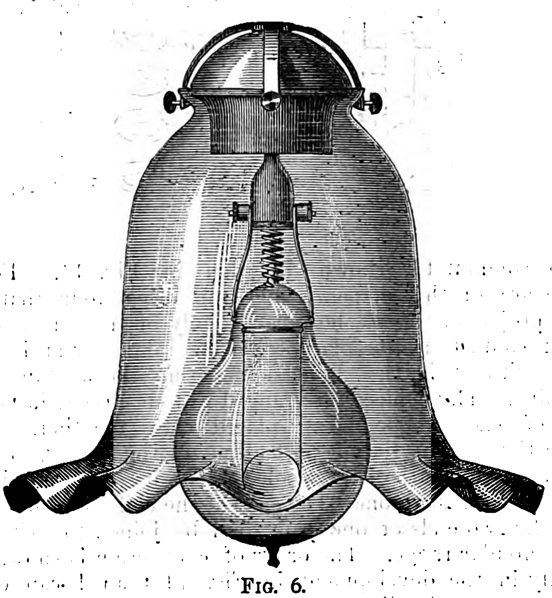

FIG. 6.

ably rather over 100 volts. About 5,000 watts will therefore be expended in the fields.

With the exception of the lamps in Messrs. Verity Bros.' large flower basket chandelier, which will be remembered in connection with the Edison Company's exhibit at the Crystal Palace Exhibition, and those in a handsome cut glass chandelier made by Defries and Son, the lamps have all been placed on simple wooden supports, the majority being arranged in groups of five, as shown in Fig. 5, and fitted with coloured shades, the remainder being fixed as single light pendants, of which an example is given in Fig. 6, which is illustrative of the Swan lamp. There is no doubt but this exhibit is admirable in every respect.

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DYNAMO-ELECTRIC GENERATORS.

(CONTINUED FROM PAGE 282.)

*Brush.**

The armature of this machine, one of its most peculiar characteristics, is a cast-iron ring nearly severed in two parts by a circumferential slot, and with three ring-shaped grooves, on each side, for the purpose of ventilation and prevention of induced currents in the iron. On each side of the ring are eight or more wide radial grooves cut into a considerable depth. The ring is mounted on a frame and spindle, and the grooves are wound full of wire, so that the faces of the ring are again made flush, while the turns are held in position by the projecting sectors between. These are also intended to intensify the magnetic field, to which end the armature is mounted between two horse-shoe magnets with wide polar extensions. These magnets are so placed that like poles oppose like, being but little more than the width of the ring apart, so that the clearance is very slight. The magnets are mounted on L shaped rails, the pieces joining the magnets are the bearings, and the whole is calculated for standing hard usage. The connection to the commutator blocks is totally different from that of any other machine, and one of the objects sought is to cut out the two coils, which are in the inactive part of the field, and to do the same for each pair successively, so that their resistance shall not enter into the circuit. Each opposite pair of coils are connected so that the opposite currents induced in them flow in one direction as regards circuit. The ends are then carried through a hollow shaft to eight strips

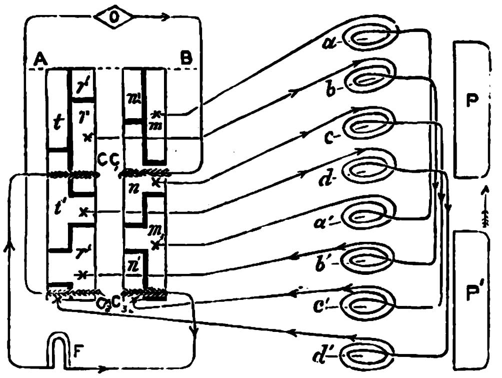

FIG. 14.

of a commutator shown in plan in Fig. 14. Four of these are of the shape *m'*, and the other four that of *m*. The projection on *m'*, however, is only of use for affording a wider contact, as its place could be taken by an insulating piece without in the slightest changing the working of the machine. These pieces are ranged in four circles, in two sets, one of each shape being placed close together, and the projection of the adjacent part filling up the space that is left. The relative length of the whole strip to its projection is about three and a half to one. The ends of the coils are connected, so that the two ends of one pair shall be joined to strips in the same circular range. The order of connection is shown more plainly in the development in Fig. 14 than I can explain. There are four binding posts, and four brushes, C C_1 C_2 C_3, C and C_3 being joined to the field terminals, and C_1 C_2 to the external circuit.

This method of joining makes the current pass in successive stages of a revolution, the order being: first, magnetic field, two pairs in parallel circuit, external circuit, one pair; and then, field, one pair, external circuit and two pairs in parallel circuit; and so on, alternating, six coils being in operation, and one pair cut out for one eighth of a revolution.

The current developed is of high E.M.F., the particular size described driving 16 arc lights, requiring about 35 volts at the terminals of each lamp. The iron heats moderately, but the machine can be run for long times without any trouble.

There seems to me to be an opposed action, which tends to lessen the efficiency of the machine. The opposing poles of the field magnets being of like character, they tend to set up on opposite sides of the ring poles which are in opposition to the primarily induced poles. This is not of so much matter, for the ring being nearly divided, this influence is much lessened. But there are, I think, two directly opposed influences to generate a current besides the internal polar influence. First, there is the passage of conductors through a magnet field, and this should be the greatest where the field is greatest; that is, at *right angles* to the brushes. On the other hand, because of the ring projections there must be a distinct *polar* effect, notwithstanding the fact that the coils are wound in the other direction—that is, parallel to, and not around these cores, and the point where these currents would be changed would be where the field is strongest. If the field magnets were small, this would be at right angles to the commutator line—that is, the times of changing the current under the two influences do not coincide, but are 90° apart. Because of the polar extension, and a very equable distribution of field magnetism, it is probable that there is a period equal, perhaps to a fourth of a revolution, in which the polar action is nothing, and the period of magnetisation and demagnetisation is limited to a zone which embraces but a short distance each side of the commutator line. This machine is part of a system in which the lamp plays an important part. Of this latter I will make some further mention.

* Descriptions and illustrations of the Brush machine have appeared in *The Electrician*, Vol. X., pp. 271, 379.

*Schuckert.**

This is also a high-tension machine. It consists of two vertical frames curved in the middle, and open on one side, so as to allow of the removal of the armature, between the upper and lower ends of which extend two cylindrical field magnets. The centres of these are widened and slotted to receive the rim of the armature. The magnets are wound so as to make each of the slotted sections a compound pole, and extend some distance on each side in the plane, or parallel to the plane, of revolution. The armature is a thin one, is built up of a number of thin discs insulated from each other, and wound in the fashion of the Gramme ring according to the tension desired. The connections to the commutator strips are by screws, to admit of disconnection for repairs. The machine runs quietly and steadily, and seems to be an efficient one.

Maxim.†

Briefly, this machine may be described as having a built-up cylindrical armature wound on the Pacinotti system and rotated in a Siemens field. The cylinder is composed of a series of thin discs punched out of soft iron, with projections on the outside, or on both outer and inner sides, something like widely spaced teeth. These are insulated from each other, and when all together form a cylinder with wide grooves, and with air spaces in the ribs or between the teeth. By having the projections between the coils the magnetic field is intensified, and by not crowding the outer surface, the inner turns are given a fair amount of room. The field-magnets are vertical, and are made of a range of bars with curved middles, the ends being connected by solid plates. They are wound so as to form two compound poles. The connections to the commutator are exactly like those of the Gramme machine.

Sometimes two distinct systems of coils are wound on the same bobbin, and a commutator being placed at each end, and the brushes connected with a junction block, several arrangements of circuits may be made to suit the work required to be done. A very ingenious device is fitted to some of the machines, but one which does not act on a true principle—that is, one to be really commended. The brushes are mounted in a movable arm, which can be rotated around the spindle of the armature so as to shift the line of contact. This is connected by gearing to the middle of three cog-wheels, which are geared together. The upper and lower wheels are on the same spindles as two ratchet wheels, between

* Vide *The Electrician*, Vol. XI., p. 519. † *Ibid*, Vol. VIII., p. 228

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which is suspended a tongue, which has a to-and-fro motion imparted by a rock-shaft and pulley deriving motion from the armature spindle. If the tongue is lifted up it engages the upper wheel and pushes it forward step by step, imparting motion to the commutator brushes. If the tongue drops it engages the other wheel, and the opposite motion is imparted. Two sets of magnets, whose keepers are regulated by springs, are placed on the top of the machine; one is for use in series and the other on a shunt. To one of these is hung the tongue and the keeper regulated to keep the tongue clear when a certain potential exists at the magnet terminals. This arrangement works very well where small currents are used, and may be of service when a machine is used for exciting another, as is done in the Maxim distribution; but it is evident that the proper place for the brushes is at the point of least sparking, and, were heavy currents used, much trouble would result. The machine is compact, well made, and efficient.

*Bürgin.**

The field-magnets are of cast iron, cast in two pieces, fitted together and bolted at the flanges, and accurately bored out to receive the armature with a certain clearance. The armature is built up of eight hexagonal hanks of soft iron wire wound on a small star frame, which is strung on the spindle. The spaces between the arms of the star frame are wound with insulated wire, the coils being thicker in the middle to bring the general shape nearly that of a circle. The hanks are strung on so that any hank is one forty-eighth part of a circumference in advance of the next. This brings the last hank that amount behind the next succeeding one at the other end. The last ends of the coils at the commutator end of the armature are connected with the advance ends of the coils at the other end, which are but one forty-eighth removed. The first and last ends of the intermediate coils are connected seriatim, and the bights of all connections joined to the strips of the commutator in succession, there being as many strips as there are coils. The brush-holders are ingenious, and the whole machine is mechanically thoroughly well made, is compact and easily handled, and fairly efficient. I think it would be better not to cut out as many coils as is done by the practice of using a flat brush in contact with five or six sections of the commutator. In removing the armature care must be taken not to bruise the coils, as may easily be done.

(TO BE CONTINUED.)

INTERNATIONAL INVENTIONS EXHIBITION, 1885.

The preliminary arrangements for the Inventions Exhibition, which is to succeed the "Healtheries," as the latter did the "Fisheries" last year, are already settled, and a meeting of the executive was held on Wednesday to consider the division of space and other matters. The exhibits will be classed under two grand divisions, the first consisting of apparatus, appliances, processes, and products, invented or brought into use since 1862, the second consisting of music. These divisions are in turn subdivided into 34 groups, each group containing a separate class of exhibit. Among the groups which will probably form the principal features of interest are Mining and Metallurgy, comprising the machinery used and actual processes of quarrying, foundry work, &c.; Engineering, together with the making of roads, docks, harbours, &c.; Railway Plant, Aeronautics, Hydraulic Machinery, Electricity, Firearms, Explosives, Paper, Printing, and Stationery, and Photography; while under the division Music will be included Instruments of the Ancients and Historic Collections. It will be seen that a very much larger number of machines and machinery in motion will be included in next year's show than has before been attempted. In the grounds the various processes of mining and ore washing will be exhibited and explained.

* Vide *The Electrician*, Vol. VII., p. 229.

EXPERIMENTS ON THE EFFICIENCY OF INCANDESCENT ELECTRIC LAMPS.*

BY HORACE B. GALE.

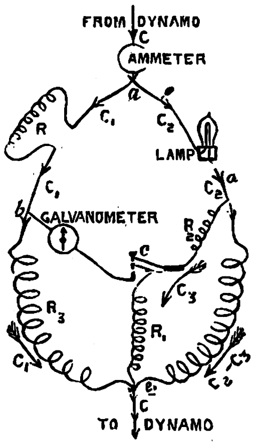
(CONTINUED FROM PAGE 258.)

PART II.

There were thus two simultaneous measurements of current to be made. As there was, however, but one reliable ammeter at the writer's disposal, an arrangement was devised by means of which the strength of two electric currents—for example, the current through the lamp and the current through a resistance coil in derivation with the lamp—could be compared with each other by means of the Wheatstone bridge.

As this method is the most accurate one known to the writer for comparing strong currents of electricity, and as it requires no special apparatus except an ordinary Wheatstone bridge, it will be described in full, in the hope that other experimenters may find it useful. The arrangement will be understood from the accompanying diagram.

The current C, from the dynamo, passes through the ammeter, and divides at the point *a*, between the two branches, *abe* and *ade*, of the circuit, one portion of the current, whose strength is denoted by C_1, passing through the resistance coil, R; and the other, C_2, passing through the lamp, which stands in its place at the end of the photometer bar. *be* and *de* are two coils of heavy copper wire of small resistance, but exactly equal to each other, the resistance of each being denoted by R_3. After traversing these coils, the currents C_1 and C_2 unite at *e* and return to the dynamo. *de* and *ce* are two arms of the Wheatstone bridge, whose resistances are marked R_2 and R_1. The bridge proper, containing the galvanometer, is from *b* to *c*, the circuit through it and the resistance coils, R_2 and R_1, being closed in the ordinary manner by a double key at *c*. When the key is closed, a small portion of the current C_2 is shunted around *de* through the coils R_2 and R_1 of the bridge. This current is denoted by C_3. Then the current passing through the portion *de* of the circuit is $C_2 - C_3$, as indicated in the diagram.



In using the apparatus, the arm R_1 is made a certain fixed resistance, say 1,000 ohms. The resistance R_2 is then adjusted until, on pressing down the key, no current passes through the galvanometer. The points *b* and *c* are then at the same potential. It follows that the difference of potential from *b* to *e* is the same as the difference of potential from *c* to *e*. But the difference of potential, or the electromotive force, between two points of a circuit is the product of the current and the resistance between those points.

Therefore, $C_1 R_2 = C_3 R_1$, or $C_3 = \frac{C_1 R_3}{R_1}$.

Our purpose, it should be remembered, is to ascertain for each lamp the variation in candle-power and current strength as the electromotive force is increased, for which object it is necessary to vary the candle-power by a series of steps, and take simultaneous observations of the current and electro-

* Reprinted from *Van Nostrand's Engineering Magazine*.

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motive force at every point. Knowing in each case the value of the total current C, if we can find the ratio between the currents C_1 and C_2 traversing the two main branches of the circuit, we shall have not only the current flowing through the lamp C_2, but, by multiplying the resistance of the branch *abe* by C_1, we may obtain the electromotive force.

Our object is now to find the ratio between the currents C_1 and C_2. It is evident that the electromotive force from *d* to *e* is equal to the sum of the electromotive forces on *de* and *ce*; or, using instead the products of the currents and resistances on these branches, we have

$$(C_2 - C_3)\, R_3 = C_3\, (R_2 + R_1)$$

Substituting for C_3 its value $\frac{C_1 R_3}{R_1}$ previously found, we have

$$\left(C_2 - \frac{C_1 R_2}{R_1}\right) R_3 = \frac{C_1 R_3}{R_1}\left(R_2 + R_1\right).$$

Clearing of fractions,

$$C_2 R_1 - C_1 R_3 = C_1 R_2 + C_1 R_1.$$

Transposing and combining,

$$C_2 R_1 = C_1\, (R_1 + R_2 + R_3)$$

or

$$\frac{C_2}{C_1} = \frac{R_1 + R_2 + R_3}{R_1}$$

When the resistance R_2 of each of the equal coils of large copper wire is so small in comparison with the other resistances that it may be neglected, we may write

$$\frac{C_2}{C_1} = \frac{R_1 + R_2}{R_1}.$$

Expressing this equation in words, we say that the current passing through the lamp is to the current passing through the resistance coil R_1 as the sum of the resistances of the fixed and variable arms of the bridge is to the resistance of the fixed arm.

Having thus found the ratio between the currents in the two branches of the circuit, and knowing also by observation of the ammeter the value of the total current C, which is the sum of the two portions C_1 and C_2, it is an easy matter to find the absolute value of the current in each branch of the circuit. The electromotive force on the branch *abe* is thus computed by multiplying the resistance of that branch by the current passing through it, and this gives us the electromotive force between the terminals of the lamp, after deducting the trifling amount necessary to overcome the resistance of the wire in the branch *ade*. The horse-power expended in the lamp is then found by multiplying together the values of the electromotive force and the current, and dividing the product by 746.

The resistance R_2 of each of the equal coils *be* and *de* was in this case only 0·424 ohm, and the fixed arm of the bridge was generally made 1,000 ohms. The value of R_3 was not neglected in the calculations, but as the error that would have been caused by its neglect would be in the fifth decimal place, its use was an unnecessary refinement. The above method of ascertaining the electromotive force and current of an incandescent lamp possesses several practical advantages over any method in which the lamp itself forms one arm of a Wheatstone bridge. First, no special apparatus is required; second, instead of passing the entire current constantly through the coils of the bridge, we may, by adjusting the resistance of the fixed arm, reduce the current to a strength just sufficient to obtain deflections of the galvanometer; third, while the current passes constantly through the lamp, the circuit through the bridge is closed only when the key is depressed. It was found that with ordinary care the ratio of two currents could be thus ascertained accurately to four decimal places.

Precautions Observed.

The accuracy of this method of comparing currents evidently depends upon the exact equality of the resistances of the two coils, *be* and *de*. They consisted of No. 6 copper wire, covered with paraffined cotton braid. Such wire will carry fifty amperes without warming perceptibly, and as the currents used in these experments rarely exceeded two amperes, there was no danger from unequal heating of the two coils. Before beginning the tests, these coils were adjusted to equality by means of the Wheatstone bridge, the final adjustment being made by a sliding contact resting on the wire, with the galvanometer so sensitive that a variation of $\frac{1}{100}$ of 1 per cent. was perceptible. Their equality was again tested at the close of the work. To insure that the two coils should always be at the same temperature they were wound on a frame into a single loose coil.

It was also important that the resistance of the coil R should not be altered by the passage of the current. This coil consisted of about 200 ohms of No. 18 German silver wire. It was wound with silk, and hung loosely over a frame, so that the air could circulate freely through it. The current traversing it never exceeded one ampere, and was generally much less, so that it did not warm perceptibly. This coil was also arranged so that it could be instantly taken out of the circuit and connected with the bridge, and its resistance measured at intervals during the progress of a test. It was found that the error due to the heating of this coil never exceeded $\frac{1}{10}$ of 1 per cent.

This part of the work was carried on at times by two observers, one of whom observed the ammeter and the bridge, while the other took simultaneous observations with the photometer. At other times the writer alone took all the observations, reading first the ammeter and the bridge, then the photometer, and then, to ensure that no change had occurred, again reading the ammeter and bridge.

The Photometric Tests.

In these, and all the observations with the photometer, five or more readings were taken at every point, and their mean used as the true reading. After considerable practice, these photometric readings could be made quite exactly.

In these measurements a Carcel lamp burning colza oil was used as a standard of light, the employment of a candle for this kind of work being impracticable for various reasons. In order to obtain as steady a light as possible from the Carcel the top and bottom of the flame were diaphragmed off, and only the middle, or least variable portion, was used as a standard. The width of the aperture was adjusted so that the lamp gave an average of about ten candle-power. Though the light of the Carcel lamp was not subject to sudden fluctuations, like that of a candle, and would remain practically constant during a single series of observations, there was nevertheless a slow variation, due to the gradual crusting over of the wick, and to differences in the temperature of the room at different times The error from these causes was eliminated, as far as concerned the variation in the candle-power of each individual lamp, by taking always a series of observations in which the candle power was gradually increased, and immediately following it by another series in reverse order in which the candle-power was decreased to the starting point.

The results of these observations, then, while showing accurately the relative changes in the candle-power of each lamp for given variations in electromotive force and current, could not be implicitly relied upon for comparisons between different lamps.

Accordingly, while the electrical quantities were here obtained in absolute measure, it was not attempted in this part of the work to measure candle-power with absolute accuracy, but merely to obtain the data from which a curve could be constructed for each lamp showing on some arbitrary scale the variation in candle-power with different electromotive forces.

The remaining problem was to reduce all these curves to the same absolute scale. One of the lamps was next run for some eight hours at about its rated candle-power, and very carefully compared with a standard candle, measurements being constantly taken of the candle-power, current, and electromotive force.

The candle was hung on the arm of a balance made for the purpose, and the time required for the consumption of each twenty grains was noted, and the proper corrections made. Several standard candles were used, all of which were obtained from Tufts Brothers, Boston, and burned very nearly 120 grains per hour.

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The average of the above observations gives us the absolute candle-power and electromotive force for a single point on the curve of this individual lamp. To get the entire curve into absolute measure it is simply necessary to change the scale of the diagram to conform to this measurement. Having done this, we have two correct curves for a single lamp, in which abscissas represent volts, and ordinates represent, in the one curve, amperes of current, and in the other candle-powers.

Direct Comparison of Efficiencies.

The remaining curves were next reduced to the same absolute scale by a system of direct comparisons of the lamps at opposite ends of the photometer.

The method consisted in placing at one end of the photometer bar a lamp whose curves of candle-power and current had been already obtained in absolute measure, and at the other end the lamp whose curve was to be deduced to that standard. The lamps were then run at their rated candle-power, and their relative brilliancy ascertained by the photometer. If the two lamps were the same kind, or required about the same current strength to bring them to their normal brightness, they were connected in series, and the strength of the current through both ascertained by the ammeter. In other cases they were placed in multiple arc, adjusted to the proper relative candle-power by a variable resistance in one branch of the circuit, and the current through each branch measured by the bridge method.

By thus obtaining accurately the ratio of the currents flowing through two different forms of incandescent lamps while they are running at a given relative brilliancy, and knowing from our previous experiments the ratio of the resistances of the two lamps with these given currents, the *relative efficiencies* of the lamps are ascertained independently of the absolute measurements.

Having obtained in this way the relative candle-power of two lamps at two given points on their respective curves, it is simply a matter of altering the scale of one diagram to bring both to the same absolute standard.

The great advantage of this comparative method lies in the fact that as but one absolute determination of candle-power is made, this one can occupy a good deal of time, and be made with great care, and further, that as the *relative* efficiencies of the different lamps are ascertained by comparing the light of one lamp directly with that of another, while at the same time the relative values of the currents and electromotive forces are obtained by direct comparison, any errors that may be made in the absolute measurements will affect all the lamps alike, and *cannot alter the relative efficiencies.*

It is, of course, impossible in a brief memoir to describe all the details and precautions against error employed in work which extended over a period of about two months. Therefore, having given a sufficient account of the methods used to enable one to form a fair idea of their reliability, we now pass on to consider

The Results.

The first result of the experiments just described was a series of curves, showing for each individual lamp tested the value of the current strength in amperes, and the candle-power, for a range of electromotive forces, from the point where the carbon is barely incandescent to a point where the lamp is given four or five times its normal candle-power. These results were carefully averaged for each class of lamps. The method of averaging was to take lamps of the same kind, not at the same candle-power, but at the same electromotive force, as they are intended to be run in practice, and find, from the curves for the separate lamps, the values of the candle-powers and amperes at intervals of five volts. Then the average of these values was taken at each point, the average resistances being computed by dividing the number of volts by the average number of the amperes. This gives to all the quantities the same mean values which they would have in an actual case where the lamps are run in multiple arc.

The average results have been represented graphically, and are shown by the diagrams hereto annexed. The curves of equal illumination have already been referred to. The next curves plotted were intended to show, for each class of lamps, the relation between the electromotive force, current, and resistance. [Diagrams were drawn to show the results.] Some of these diagrams were constructed on what the author thinks a new plan, which he describes in these diagrams. Electromotive force in volts is laid off on the horizontal scale at the top, and the curve for each lamp is so constructed that the height of any point on it represents on the vertical scale at the right the resistance of the lamp in ohms, under the corresponding electromotive force. It is also desirable to show the current which will flow through the lamp under a given electromotive force, and also the resistance of the carbon when a given current is passing through it.

(TO BE CONTINUED.)

LEGAL.

Metcalf v. the London and Globe Telephone Company.

This case came before Mr. Justice Pearson in the Chancery Division of the High Court of Justice a few days since. It was a motion on behalf of the plaintiff that the defendants might be restrained, by injunction, from carrying out a certain provisional agreement dated the 24th of June, 1884, and made between the United Telephone Company and the defendant company for the purpose of effecting a sale from the defendant company to the United Telephone Company. It appeared that a meeting of the shareholders of the defendant company had taken place on the 16th July, at which it was proposed that the directors should be at liberty to carry out the sale of the company to the United Telephone Company on the terms of the agreement, with such modifications as they should think beneficial under the circumstances. After a long discussion, an adjournment of the meeting was moved till the following Monday. This motion was put to the meeting by the chairman, and, on a show of hands, was declared to be carried. A shareholder then demanded a poll upon the question of adjournment, and this having been put into writing was carried out, when there appeared in favour of the motion 6,505 votes against 16,640 votes. The chairman thereupon declared that the motion for the adjournment of the meeting was negatived, and a resolution was then carried in favour of the proposal to carry out the sale. The present motion was resisted upon the ground that the meeting of the 16th July was irregular, and that the resolution approving of the sale was not legally passed.

Mr. Everitt, Q. C., and Mr. T. L. Wilkinson appeared in support of the motion; and Mr. Higgins, Q.C., and Mr. Beale for the defendants.

Mr. Justice PEARSON, after discussing the technical objections which had been raised to the validity of the course taken at the meeting of the 16th of July, came to the conclusion that the resolution had been legally passed, and that the defendants—the directors of the London Telephone Company—were at liberty to carry out the agreement for sale to the United Telephone Company. The motion was therefore refused, with costs.

The United Telephone Company v. Graham.

In the Chancery Division of the High Court of Justice, on Friday, the 1st inst., on the application of Mr. Fletcher Moulton, the Vice-Chancellor granted a perpetual injunction against the defendant's manufacturing, selling, supplying, letting on hire, or using any carbon telephone transmitters, or Blake telephone transmitters, or any other instrument manufactured according to, or in a manner only colourably different from the specifications of the plaintiff company's various patents.—The defendant appeared in person, and offered no opposition.

United Telephone Company v. London Globe Telephone Company.

In the High Court of Justice, Chancery Division, before Vice-Chancellor Bacon on the 4th inst., an action was brought by the plaintiff company for an infringement of the Edison patent.

Mr. Moulton appeared for the United Telephone Company, and informed his lordship that the defendants had agreed to the minutes of the judgment with the exception of one slight verbal admission which the Registrar was to decide.

Judgment was given accordingly.

In re the Great Western Electric Light Company.

On the 6th inst., in the Chancery Division of the High Court of Justice, Mr. Justice Day made an order for the reduction of the capital of this company (£250,000 in shares of £5 each) by in effect turning the £5 shares into shares of £2 10s.

Mr. Phipson Beale appeared.

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COMPANIES' MEETINGS & REPORTS.

Anglo-American Telegraph Company (Limited).

The ordinary general half-yearly meeting of the proprietors of this Company was held at the City Terminus Hotel, Cannon-street, on Wednesday last under the presidency of the Right Hon. Viscount Monck.

The SECRETARY (Mr. T. H. Wells) read the notice convening the meeting and the minutes of the last meeting.

Mr. T. SMITH (of York) then requested that the report of the directors should be read paragraph by paragraph, which was accordingly done by the secretary.

The CHAIRMAN afterwards said: Gentlemen, it now becomes my duty to propose to you the only resolution that the Board will submit to you at this meeting: "That the report of the directors with the accompanying statement of accounts to the 30th of June, 1884, submitted to this meeting be and the same are hereby received and adopted." Gentlemen, before I proceed to say anything upon that resolution a melancholy task devolves upon me. You have heard in the report that we have sustained the loss of one whose countenance at these meetings had become a familiar feature, and who exercised a great and a justly great influence upon the proceedings of your Board. The late Hon. Robert Grimston was no common man. His almost unrivalled experience in the management of telegraph companies gave him a grasp of the general principles upon which they should be conducted. His uprightness and honesty of purpose and his exactness in the transaction of business insured for his opinions a favourable reception even on the part of those who differed from him, and his energy and force of character enabled him to put forward his views on every subject with vigour and effect when it was necessary to do so. Gentlemen, if it had been thought expedient on other grounds to appoint a director in his place, it would have been difficult if not impossible to find one who would adequately fill the position that he occupied at this Board. Having paid this unavailing and imperfect tribute to the memory of one for whom, after a long period of association with him on your Board, I entertained a profound respect and a deep personal regard, I now come to deal with the subjects mentioned in the report. The first matter to which I will allude is the condition of your property. We are, as you know on the eve of another of those great competitions which have exercised so baneful an influence upon our interests, but whatever the result of that competition may be, we, at all events, embark on it under good auspices. Your property is in perfect order, and although the earnings of the last half year do not compare favourably with those of the corresponding half of last year, the diminution is not due to any inefficiency in the performance of the functions of the Society, but rather to the depression in trade which still exercises its injurious influence upon all undertakings of this description. Gentlemen, with regard to one resolution which was proposed, but not adopted, at the last half-yearly meeting, namely, with reference to economy, I am glad to inform you that what was said by my noble friend on my right (the Marquis of Tweeddale) on that occasion has been realised and practised during the half year of which we are now discussing the results. The expenditure of that half year is £4,805 14s. 11d. less than that in the corresponding half of 1883. I do not for one moment mean to say that you are to look forward to anything like a corresponding reduction of expenditure in future half years, because that would land us in a *reductio ad absurdum* in the end of managing our affairs without any expenditure whatever. But I think it shows you that your Board are attentive to the question of economy, and desire by every means in their power to reduce the outlay at which your work is done. Well, gentlemen, I do not think there is anything else of what I may call non-contentious matter with which I need trouble you. I now come to what I suppose I may say will be the great bone of contention at this meeting, namely, the amount which should be laid by to the renewal fund. Now, gentlemen, I have been for a great many years chairman of this Company, and I think I have lived my life during that period to some discredit if I cannot call upon you to admit that I have always been ready whenever I could see my way clear to do so consistently with my duty to the Company to consult the wishes of the shareholders in all matters which they brought before me. But gentlemen, with regard to this matter of the amount to be laid by to the renewal fund, I cannot bring myself to concur with the resolution, or recommendation rather, that was passed at the last meeting ["Resolution"]. I hope you will hear me patiently, and give me credit for sincerity in stating the reasons why I should have come reluctantly to that conclusion. Now it sounds almost like a truism to say that in order to earn a dividend, or to earn money, you are bound to take proper measures to keep your plant in order. That is a truism, of course, in reference to all undertakings. But let me say that, looking to this matter merely from a shareholder's point of view, you are bound as a natural law which applies to all enterprises to be perfectly certain that you are in a position to maintain not only plant sufficient to earn a dividend, but an amount of plant equal to retain the income which you now possess. Gentlemen, you are all aware that you are operating not as an ordinary company. You do not receive your income direct from your customers. You receive only a share of the gross income derived from telegraphy across the Atlantic by what is technically termed the "pooling" of three companies. Now, the conditions upon which you obtain that income are that you should maintain in full efficiency not merely a cable but a particular number of cables, the same number which you had when you entered into that agreement, and if you take any step which will prevent you from carrying out that arrangement, and a catastrophe should happen which you would be unable to meet, your income would fall beyond what any competition could deprive you of. Well, gentlemen, that is looking at the question from merely a shareholder's point of view, and with reference to dividend. But you must forgive me for saying that your directors are compelled to look at this question from another point of view. You are bound by your interests, as I said before, to keep your property in such a condition as to earn money for you. Your directors are bound by the law of the land so to manage your income that the first object attained should be the maintenance of your property as a going concern in proper order. Now, gentlemen, that I believe is law. I have beside me our legal adviser, who will tell you so, and that I believe is sound law; and let me add that it is sound law in a manner which is very disagreeable to directors, because recollect the majority of the shareholders by a vote cannot shield the directors. If such a catastrophe as that which I have alluded to should take place any shareholder might bring an action against the directors, and make them personally responsible for the dividend which they had declared in prejudice to that contribution towards the renewal fund which on reasonable grounds is so necessary to maintain your plant in a proper condition. Any shareholder who was discontented, on finding that either the revenue derived from the joint-purse arrangement was reduced or that you were obliged to raise money by debentures or otherwise for the renewal of the plant, might bring an action against the directors ["No, no"] and make them personally liable. It is all very well to say "No," but the highest authority at our English bar has advised that that is the law of the land, and I do not expect that any body of shareholders will call upon directors to put themselves in such a position as that. Gentlemen, we have anxiously and carefully, and with the utmost desire to comply with the wish of the shareholders, looked into this question. I entirely decline to commit myself to any statement as to what is the proper life of a cable for this simple reason, that we have only had the experience of 19 years in deep sea Atlantic cables, and that during that period we have had only one cable which has reached the age of 15 years, and that that cable has cost us a large sum of money to maintain it in its present position. With only these facts it would be absurd for me to attempt to give you any definitive statement as to the life of a cable. All that we can do is to obtain the advice of the best experts we can find. We have some members on our own Board who, I believe, have as good an opinion on the subject as any man living, and we have taken the advice of others outside who are equally competent, and the advice they gave us is embodied in this paragraph of the report:—"After very careful consideration of the proposed reduction in connection with the condition of the cables, their present age and probable life, and taking the most reliable opinions which could be procured on the subject, the directors have arrived at the conclusion that, for some time to come, no diminution can be made without great injury to the prospects and property of the Company, and seriously jeopardising the proportion of gross receipts accruing to the Company under the existing joint-purse agreements." After the most careful consideration, do you think it is possible that we could maintain in a court of law that we had exercised reasonable discretion in the amount which was set aside to the renewal fund if the question was raised that we had not set aside enough. I do not think we could, and we have come deliberately to the conclusion that we cannot reduce that amount for some time to come which we have hitherto set aside to the renewal fund. Now, gentlemen, let me say that has been the decision of your Board, and by that decision the Board and myself are prepared to stand. But, gentlemen, that is not only the decision of your Board. There is a phrase that has lately been brought into use, "legislation by pic-nic," and "legislation by consulting the polls." Now we do not attempt legislation by pic-nic, and we do not want to consult the polls; but we have an intermediate system by which we can very easily ascertain the opinions of the great body of our constituents. Nothing can be plainer, I submit, than the manner in which the issue on this subject is stated in the report. We state, as I have already read to you, that we cannot faithfully reduce the amount that has been hitherto set aside for the renewal fund, and we say "the directors look with confidence to the great body of the proprietors for their co-operation and support in the maintenance of the renewal fund, upon the sufficiency of which the whole existence of the Company depends." Gentlemen, we have put that report before the shareholders. We have asked them to send us their opinion of it in the shape of proxies, and this is the result [showing list of proxies received]. Under these circumstances, gentlemen, backed, as we feel we are by the great body of the shareholders of this Company, we cannot refuse to give effect to their wishes and to our own determinate conclusions, and though I reluctantly differ in opinion from any body of shareholders of the Company, I am bound to say that the Board and I myself are steadily resolved to maintain at present the amount hitherto set aside to the reserve fund.

The Most Hon. the Marquis of TWEEDDALE seconded the motion.

Mr. A. J. BAKER wished to ask how much the proxies that had been received represented, and whether the holdings of the Globe Company and the Submarine Trust were included amongst them?

The CHAIRMAN replied that the amount of stock represented by the proxies was about two and a-half millions, and begged to suggest to the hon. proprietor that it was a very invidious sort of thing to lead it to be inferred from what he said that the Globe Company had not as great an interest as anyone else in maintaining the dividend.

Mr. BAKER dissented from this view on the ground that the Globe Company made up its dividend from a number of other stocks.

Mr. MOON asked whether it would be desirable to give the meeting an estimate of the probable cost of a new cable, supposing that one of the present ones fell into disuse? It might be of use to answer the question in considering the amount necessary for the renewal fund.

Mr. PRUST wished to remind the shareholders that the renewal fund was now £640,000, and it would soon be over a million. Now, the stock of the four cables stood in the market at about two millions, although the original price would have been about seven millions. That no doubt was

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a very deplorable state of things. It was a fact, he thought, that it was their enormous reserve funds which caused the stocks of banks to stand so high in the market, and therefore, considering the competition that was likely to take place, there was no doubt that the reserve fund would be their best friend. He really thought, however, after all was said and done that £3,000 a year for directors did appear a very large sum for the personal attention they occasionally gave to the affairs of the Company, and more especially when he observed that they were all wealthy men. When the majority of the shareholders were getting nothing, and their property was disappearing, the amount was too large.

Mr. JACKSON thought that it was a most important question to the majority of the shareholders to know what was the limit they intended to fix the renewal fund at. The sixth paragraph said, "The Company's system of cables is in good working order." He thought that under these circumstances, and as a matter of justice to the proprietors, the time had now come when some return should be made to them on so large a proportion of the capital as was represented by the reserve fund. The last paragraph which the Chairman had quoted from the report said, "The directors look with confidence to the great body of the proprietors for their co-operation and support in the maintenance of the renewal fund, upon the sufficiency of which the whole existence of the Company depends." Now he regarded that as a rather exaggerated statement, and one with which the shareholders would hardly agree. If that were so where would be the railways and other undertakings which had no reserve fund or renewal fund? He did not mean to say that the telegraph business exactly resembled these, and admitted that there was a necessity for a renewal fund; but in view of the present condition of this Company he thought it was about time to limit it, and give the shareholders some return on their capital. He did not hesitate to say he was most anxious to support the Board, and was opposed to any division of feeling between the Board and the shareholders if it could be avoided. Nobody would regret more than he would that an eminent directorate like theirs, containing as it did gentlemen of the greatest experience and standing, and having a long connection with telegraph business, should be interfered with in their conduct, as most assuredly would be the case if the policy of the Board was insisted on. It was a monstrous assertion to say that upon the sufficiency of the maintenance of the renewal fund the existence of the Company depended. Did it not depend on the enterprise and development of the resources of the Company? It was an insult to men of business in the City of London to say that was the foundation of all success in business. The position of the Company was unsatisfactory, and a better result ought to be shown. He did not say he could do it, but that was no answer to him. The fact remained that the business had steadily declined for years.

Mr. T. SMITH (of York) moved "That, inasmuch as the directors of the Anglo-American Telegraph Company have failed to carry out the resolution passed by a majority of the proprietors at the annual meeting held in February last, this meeting rejects the report now submitted so far as relates to the sum of £75,000, set apart to the renewal fund." At that meeting in February the shareholders were told that the directors had nothing but the interests of the Company at heart, and that if he withdrew the amendment he then proposed, which was similar to that which he had just read, the directors would give effect to the resolution with regard to the renewal fund which was passed by a majority of proprietors at the large meeting he referred to. [Voices: "It was only a recommendation."] He begged to say that it was stated to have been passed. He understood then, and the shareholders also believed, that that resolution would be carried out. But to his surprise, in the middle of April he thought it was, they had carried forward £37,500 to that account. The directors spoke about having the interest of the Company at heart. Was that their way of expressing it? It was the very thing that sent the stock down, and the price of stock was a barometer of the credit of a company. In that very room their worthy chairman, the Marquis of Tweeddale, told him when he brought the matter forward on that occasion that the purport of the resolution was a valuable suggestion, and would have the attention of the Board. He thought they would have had some result from that promise before now, but no result had followed. The directors asked for the confidence of the shareholders. He had come to London for many years, and he had heard many reports about the "confidence trick," but the way the Board were dealing with the renewal fund beat all the "confidence tricks" he had ever heard of. There was just now a confidence trick, consisting of a renewal fund of £640,000. He did not see how they got it, but it was there. It was put down in the accounts. Well, some fine morning they would find it would have gone over to their friend the Maintenance Company. They would find that they would require some new cable laid or some extraordinary cable mending, and that was where it would go. They had paid the Maintenance Company, he believed, £600,000 within the last few years. The Maintenance Company were not satisfied with a poor 3 per cent. They must have their 20 or 30 per cent., with a bonus besides. This Company formed a sort of feeding ground for it—nothing else. One of their directors was the Chairman of the Maintenance Company, and he had very grave doubts whether he had authority to sit at the Board as a director. The Companies Act of 1862 said that the directors were the servants of the proprietors, partners, or shareholders of a Company.

The SOLICITOR: What clause is that?

Mr. SMITH replied that he did not know. He was not a lawyer.

The SOLICITOR said that he was, and that that was not in the Act at all. He then read Article 104 of the Articles of Association, specifying the powers of the directors in regard to setting aside such sums as might be necessary in their judgment to meet any claims that might arise, or to provide for new works or other purposes.

Mr. SMITH said that the directors were locking up too large a sum of money, and they ought not to put by more than £100,000 per annum at the very most, which would amount in a very short time to a million of money. He concluded by formally moving his amendment.

Mr. BLUMENTHAL seconded it.

Mr. VEARS thought that if the Board acted on the suggestion of the previous speaker they would be taking a step in the right direction.

Mr. RAMSDEN begged respectfully to propose that the amount of the renewal fund should be limited to £700,000, and that no addition be made to it, except by way of interest, until the deferred shareholders had received 12 per cent. interest.

The CHAIRMAN: I am afraid you must wait till the other amendment is disposed of.

Mr. GRIFFITHS thought that the argument advanced by the Chairman as to the legal responsibility of the Board in this matter showed a somewhat unfortunate bias in the minds of the directors, and one not altogether correct from a legal point of view. The directors were not responsible for a fair exercise of their judgment. They were responsible only for fraud and gross missmanagement—amounting to fraud—nothing more. That point of law was clear, and he hoped the directors would not from any personal desire of keeping themselves free from legal proceedings be restrained from fulfilling their duty to the shareholders, or adopting a course which might be injurious to the property of the Company. One shareholder asked what would be the cost of a new cable. He thought he would not be wrong in saying that it would be about £500,000.

The SECRETARY: Much more. It is close on £600,000, and that is only to Newfoundland.

Mr. GRIFFITHS went on to say that he had ascertained from a Post Office authority that the duplication of the cables that now existed might be multiplied indefinitely, and as a matter of fact they had more cables than were sufficient to carry on the business. Then they had the direct cable they must remember, and they had £600,000—a sum more than was sufficient. Where, then, was the necessity for paying that large insurance premium every year which they were now doing, and which was really putting their money below water, and throwing it away for 3 per cent., when it might be divided as profit among the proprietors. He would vote for the amendment.

A SHAREHOLDER thought the cables were in such good working order that the Company might now go on without adding more to their reserve fund.

Mr. BUTT, in a speech of considerable length, defended the action of the Board and the soundness of the policy they were pursuing, which, he said, was unquestionably in the interests of the permanent holders of the Company's stock, though not, perhaps, in those of speculators. If the judgment of the directors was that they ought to set aside a certain amount to the renewal fund, and they acted in a manner contrary to that belief, they must necessarily be liable to the proceedings brought against them in a court of law. He thought, moreover, that the Board were as much bound to abide by the wishes of those shareholders all over the country who had sent in their proxies as they were by the behests of the shareholders present at the meeting.

Mr. NEWTON asked whether the legal opinion to which the Chairman had referred had reference to the keeping up of the capital of the Company or of its property? That was, he considered, a question of some importance. The shareholders had been given to understand at the last meeting that a new cable from shore to shore would cost about £400,000. Was that so? Because it was necessary to have some basis to go upon in estimating the amount that was necessary for the reserve fund.

Mr. MOON thought that the feeling which animated a good many of the shareholders present was not that of the shareholders who were permanently interested in the prosperity of the Company, and he was quite sure that if a poll of the whole of the shareholders of the Company were taken it would endorse the policy of the directorate.

Mr. STOCKDALE asked whether it would not be better, instead of putting a large amount to the reserve fund, to appropriate it in reducing their present inflated capital.

Mr. BLUMENTHAL said he concurred in the view expressed by the previous speaker.

The CHAIRMAN, in reply, said: Now, gentlemen, before I proceed to notice in detail the questions that have been put to me, there is one question, which as our American cousins say covers the whole ground, which I should like to notice. We have been told by a gentleman on that side of the room that the directors are the servants of the shareholders. To that principle I entirely subscribe, and I rejoice that the question which that principle involves has been raised from that side of the table, and that you have not driven me as the spokesman of the Board of Directors to make this question a question of confidence. In the ordinary relations of life, when a servant disobeys his master's orders, or when he fails to carry into effect what his master considers best for his interest, the ordinary course is to dismiss him, and my advice to the shareholders is this—if they consider that the Board of Directors are not carrying out what they believe to be for the interests of the Company, my advice to them is to dismiss them, and put others in their place. But, gentlemen, this Board, if I know anything of their opinions or their intellectual fibre, will not at the threat of any body of individuals act contrary to what they have already described to you as their deliberate opinions and as their final judgment on the facts submitted to them. We cannot go back from what we have said. We have considered this question in all its bearings. We obtained all the assistance which we could command in considering it. We have arrived at a definite conclusion, and as I have already stated to you by that definite conclusion we must stand. Well, gentlemen, having said so much on that point, I will just allude briefly in detail to the questions that have been put. A great deal has been said about the amount which has been laid by to the reserve fund, and we have been asked what limit we could put to the

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contribution to that fund. Well, gentlemen, we have four cables. We are told we have cables quite sufficient to carry the whole of the correspondence across the Atlantic. And so we have. But that is not the question which you have to consider. It is not whether we can carry the whole of the correspondence across the Atlantic, but the question is this: if we allow our carrying power to diminish we shall not receive under the joint-purse arrangement the same proportion of the whole earnings as we are now getting. It is quite plain that we should not, and I venture to state to you—if I was not able to convey my meaning in the observations I made at the beginning—that there are additional obligations on you beyond that which binds the shareholders of other companies to keep up their plant in perfect condition. As to the limit to be placed on the contribution to this reserve fund, I have told you that we have one cable that is fifteen years old, the French cable from Brest to St. Pierre. That cable, we may reasonably suppose, will break down first. The cost of replacing that would be between £800,000 and £900,000. Now, the question is, are we legally bound to keep it up? I say we are, and if we do not keep it up we shall lose all the benefits we get under the joint-purse arrangement. That is a sufficient answer to the question as to the limit of the renewal fund ["No, no."] I say that that is an answer to the question of limit, because if that cable were to break to-morrow we have not the means of replacing it, and if we have not the means of replacing it we suffer in our position in reference to the joint-purse agreement, and we render ourselves liable to any shareholder who may choose to bring an action against us for not taking the proper precautions ["No, no."] You say "No, no," but you have no responsibility, and we have.

The SOLICITOR: And that makes all the difference.

The CHAIRMAN: I confess that I was rather surprised at, and I regret to hear the spirit in which some observations were made with regard to the remuneration of the directors. I do not want to make any invidious comparisons, but I do not believe there is any company of such magnitude in London managed at so small expense to the shareholders as this Company, and in this very report, in consequence of the diminution in the Board by two directors, they have voluntarily surrendered £500 a year of what was set apart as their remuneration. The sum set apart for the remuneration of the directors was £3,000; by this report that is reduced to £2,500. We have voluntarily reduced the amount. Well, now, gentlemen, we have heard something of the claims of the deferred shareholders. Now it is rather a remarkable fact that people in the same position take different views of their interests. We have heard a great deal of complaint on the part of some of the deferred shareholders that they are getting no income; but many of those proxies to which I referred in my opening observations came from gentlemen of the same class. It is a curious fact to state that I have the proxies in support of the Board of a gentleman who holds £95,000 of deferred stock. The directors certainly derive some support in the policy they adopt from such a fact as that. Mr. Smith, in proposing his amendment, used some strong language about the conduct of the directors, and said that a resolution had been carried by a very large meeting, which meeting consisted of individuals 29 of whom were opposed to Mr. Smith's motion, so that there was a majority of 17 in favour of the resolution. There are 5,500 shareholders in this Company, and you all know that the words "great" and "small" are relative terms. A meeting of 75 would be a larger meeting if the whole body consisted of only 100, but I submit that a meeting of 75, 29 of whom were against a resolution adopted, is a very small meeting when compared with 5,500. We were asked by a gentleman to make some statement to raise the value of the stock. Well, I wish we could make such a statement, but I do not believe it is within the bounds of possibility for the Board to do so, and if we rejected the element of truth I am afraid the increased value of the stock would be of a short-lived character. Mr. Griffiths spoke of conciliatory measures, and said he hoped we would adopt some plan by which we should not have this continual wrangling going on, and another gentleman used an expression which gives a certain meaning to the word conciliation which probably Mr. Griffiths did not mean to apply to it. We were told that the directors must change their discretion; that is to say, that the conciliation must be all on one side, and that the directors—who, as I told you and maintain, are legally responsible for their acts, and may be made responsible in damages—must change their deliberate judgment in order to adopt the views of those who have no such responsibility whatever. Mr. Aston proposed that we should have some new directors. If this were a mere question of expediency and not of active principle there might be some force in it. But no addition to the Board could possibly change the deliberate opinion of the existing directors, and it would only add to the difficulty of the Board in the way of making any progress. Mr. Newton asked a question with reference to the legal opinion I quoted, and he asked whether it referred to the keeping up of the capital or the property. The legal opinion has nothing to do with the capital. We must keep up our property to meet all the obligations which the possession of that property entails on us. Some gentleman put into my mouth words which I certainly never used. He said that I quoted a legal opinion to the effect that the directors cannot use the renewal fund for any purpose except renewal. I never said anything of the kind. The legal opinion I quoted was not with reference to the application of the renewal fund, but with reference to providing a sufficient renewal fund. I should be very glad to see the capital reduced, but it is practically impossible in the present state of the law, as I am advised, to do so. We cannot go on the Stock Exchange and buy our own stock. That would be clearly illegal.

Mr. BAKER rose to speak, but was ruled out of order.

The CHAIRMAN: You can do anything by Act of Parliament, but I doubt very much if the shareholders would sanction the application of their hard earned reserve fund to buying stock in the market. It is not within the range of practical politics at the present time. With these observations I will now put the amendment to the meeting, the effect of which is practically to eliminate the third paragraph in the report. As many as are of opinion that this amendment be carried. Twenty-one. As many as are of the contrary opinion. Thirty-four. The amendment is therefore lost. He then put the original resolution, which he declared carried.

In further reply to Mr. Moon the CHAIRMAN said that the Direct Cable Company was carrying its full proportion of messages to America, and that each Company mutually bound itself to keep its cables in good condition.

Mr. BAKER suggested that a circular should be sent to the shareholders asking their opinion on the subject of the renewal fund.

The CHAIRMAN replied that it was not a point as to which the Board were at all disposed to lend their assistance, seeing that the non-contents were clearly in the minority.

Mr. WM. ABBOTT gave notice that he would move at the next meeting that Mr. Cyrus Field be requested to retire from the Board.

A vote of thanks was, on the motion of Mr. JACKSON, seconded by a SHAREHOLDER, cordially passed to the Chairman, who briefly returned thanks, and the proceedings terminated.

The Submarine Telegraph Company.

An ordinary general meeting of the proprietors in this Company was held at the Company's offices, 2, Throgmorton-avenue, London-wall, on Friday, the 1st inst. The Chairman, Sir Julian Goldsmid, Bart., presided.

The SECRETARY (Mr. S. M. Clare) read the notice convening the meeting, and the Company's seal was thereafter affixed to the register of the shareholders.

The CHAIRMAN then said: Gentlemen, in pursuance of a practice which has been established for many years in this Company, and which, since I have been your Chairman I have endeavoured to comply with, I should like to supplement, by some information which I can give you, what is contained in the report. You will all have observed that the amount which has been received for messages has somewhat decreased as compared with that of the corresponding half year. I think that those of you who were present at the last meeting will bear in mind that I then pointed out that the decrease up to that date was mainly owing to the system of condensation of messages which was prevailing, and which prevailed for several years before. I pointed out to you on that occasion that, whereas in the year preceding the average number of words in every message was over 13, during the period which was then under review it was 12·33, and I told you that in my opinion we must come to an end of the process of condensation at some fixed point or other, but what the point was I could not indicate. I have to report that during the last half year a further decrease in the number of words per message has taken place, but I am glad to say it is not so great as it was in the previous half years to which I have referred, and it rather looks as if we were coming near the end of this condensation, if we have not arrived there already. I find that up to the 30th of June, 1883, we had, as the number of messages, transmitted 1,337,009; and up to the 30th of June, 1884, we had actually an increase, though a small one, namely 1,377,419; therefore, practically, an increase of 40,000 messages. Now, the number of words was as follows:— Up to the 30th of June, 1883, it was 16,925,163, whereas during the half year just elapsed it was 16,583,147, showing a difference roundly of 380,000 against the half year which is now under review. Or, to put it in another form, in which you may understand it better, that whereas the average length of messages to the 30th June, 1883, was 12·65 words, it was in the last half year 12·04, showing a decrease of ·61 in comparing the two periods. But I said it appeared to me—and I hope that I am not deceived—that we are coming near the bottom of this decrease, and, therefore, the increase which occurs in the number of messages may benefit us. Taking month by month, in January the average length of messages was 11·92 words; in February it was 11·99; in March it was 12·15; in April it was 12·07; in May it was 12·08; and in June it was 12·02. The consequence of that, you will see, is that in January we reached the lowest point we have ever attained; and since then there has been a rise in the number of words per message, so that I hope we have reached the lowest limit. If that is so, any legitimate increase in the number of messages will redound to our credit to the extent of the increase in the receipts from the extra number of words we transmit. As I showed you on the last occasion, and I venture to repeat it now, this is a thing which is absolutely beyond the control of any board of directors. They have no power to dictate to the public what length of message they should send. Well now, to take the other side of the accounts, you will see that, notwithstanding there has been some decrease in the number of words carried, we have still had an increase in the payments which we have to make. That is a thing which the Board and myself have very carefully examined, and that again is absolutely beyond our control. Under our convention with France there are certain clerks in France who are paid by the French Government. Their salaries and their numbers are fixed by the French Government, and we have no control over one or the other, excepting by memorial or representation, which may or may not be attended to. We have recently, for instance, had a considerable increase in the pay of some of the clerks employed by the French Government in our behalf as well as a slight increase to their number. A larger number was proposed, and we respectfully addressed the French Government on the subject. Our representations were attended to, but, notwithstanding that, the result so far as the last half year is concerned is that we have had to pay £670 for salaries more than in previous half years. With regard to the increase to the Company's staff we have paid nearly £600 more. I have gone into the matter with great care, and I discovered that our rate of wages to clerks, porters, &c., is certainly not above what is paid by the Post Office. We cannot expect to get services

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of this kind at a lower rate than is current throughout the country. But we have established a system of grades with regard to clerks by which the oldest men if they are capable go into a higher class and get higher wages. Then there is a lower class, and as the numbers of the upper class are from time to time reduced by death or resignation, those men in the lower class who are capable are promoted, and in each class we are giving a gradual increase according to a scale, and it is in consequence of that that we have had to pay more for wages. But I may say that I believe this is a necessity. It is essential to pay the men a proper scale of wages. If we do not we shall not get our work well done, and that would interfere with our traffic, so that in that respect we should as shareholders greatly suffer. The Board are quite alive to this matter, Mr. Clare looks after it very carefully, and I have spent a good deal of time in examining the details myself. Now, I come to another subject which affects us very considerably, and which is of constant interest to the shareholders—that is, the expenditure upon the cables. We have expended as you will observe on the repair of cables very nearly £5,000—£4,958—which is a large sum of money. I have pointed out to you at every meeting that a constant source of trouble and anxiety to us has been the condition of what we generally call the Dutch cables. Those are cables which belong to the English Government, but which by an agreement with the Government are worked by us on their behalf. Amongst other things in that agreement as long as they were in decent repair we had, if they were broken, to repair the breakages. We had to do this on many occasions, and long before I was chairman I used to jocosely point out that as every autumn was approaching we must make arrangements for the Dutch cables to be broken; that really represented the actual facts of the case. They always did get broken, and I was under the opinion that there was something defective in the cables to be so ill-treated by the storm. We had the matter examined, and it was reported upon by our able engineer with the result that last year I came to the conclusion that it was perfectly ludicrous for us to go on endeavouring from time to time to keep them in decent repair or to undertake to mend them. They were old cables of a bad type, which none of us would lay down in the present day, and they were totally unfit to carry on the traffic. In addition to that, I was well aware that the Dutch Chamber of Commerce were making repeated representations that the Dutch traffic was frequently interrupted, and they did not think proper attention was paid to the subject. In fact, I was appealed to by the Dutch Minister, who was an old friend of mine, and I assured him that I was well aware of the fact, and that we had made strong representations to the English Government on the subject, and that we had made two alternative proposals to them, which it is unnecessary for me to trouble you with to-day, by which the difficulty might be obviated. I must say I was exceedingly well received by the Post Office authorities and the Chancellor of the Exchequer, and after a great deal of discussion and negotiation the Post Office finally decided that they would put down one absolutely new cable themselves, and would thoroughly repair the other. With regard to the first part of the promise it has been redeemed. An absolutely new cable has been laid down. It has not been completed many weeks. They accepted the offer which I made to them of giving them the assistance and advice of our engineer in laying it, and he has reported to us that it is in excellent condition. It is laid on the line across the channel that he advised, and he believes it will add materially to the traffic between Holland and England. The other cable is to be put in order by the Government by inserting a considerable extent of new mileage of wire. That being so, I believe the Dutch cables will be put in a thoroughly satisfactory condition. They have cost us, I may say, a very large sum of money. I find for instance that the communication was totally interrupted between the 13th November, 1882, and the 14th March, 1883, and again from 12th November, 1883, to the 15th March, 1884—that is to say, the two successive years—in consequence of the condition of those cables. We had our steamer out the greater part of the time endeavouring to find the ends and set them right; but until the better weather came in March it was practically impossible to get them into working order. So that from 1882 to 1883 those cables were interrupted 123 days, during most of which we were at work with our steamer, whereas during the half year ended June, 1883, the French and Belgian cables were not interrupted at all. During the half year ended 30th June, 1884, the total period of interruptions in these different cables was sixty-nine, and there was never any interruption in the traffic. That shows the difference between having good and bad cables. The expenditure therefore has been always considerably increased by the condition of the Dutch cables, and I venture to predict that in future half years we should show more satisfactory figures. Because not only is the actual cost of such work very expensive, but there is this also to be remembered—that we have to pay heavily for insurance on our steamer when she is out of harbour. The more days of course that she is looking after the cables there is less rebate on account of the insurance. I can honestly say that last year I devoted a great amount of time and attention to this matter, and I believe it is now on a satisfactory footing, and that we shall be able in future half years to give more gratifying accounts. With regard to all the other ordinary items there is nothing to be said. We have paid about the same under almost every other head except this. The steamer has been kept in good repair, but the Board are considering at the present moment the question of renewing the cylinders which have been in ever since the vessel was built. Apart from that, I do not think there is any other novelty connected with this Company. One gentleman has asked me to make an observation with regard to the investment of the reserve fund. I remember that our late respected Chairman, Sir James Carmichael (and I myself on two or three occasions touched on it) made some remarks here with regard to this matter, and I am very happy to repeat the purport of the observations made—I should say at least twenty times—and that is that the power of investment by the directors is very properly limited. They can only take debenture stock or Government Consols. That being so it is not worth while to discuss whether it is a wise and proper limitation or not. It exists, and a great deal is to be said in favour of it. All that the directors are able to do when they have money to invest on account of the reserve fund is to endeavour to get a good debenture stock or similar stock at the lowest price to be had in the market. The price of debentures has risen of late, and it does not require to be a prophet to say that they are likely to continue to rise. I should say they are. All that we can do is to get the lowest price at which we can purchase them, and that is practically what we have done. We took some South Metropolitan Gas Company debentures some time ago, because we found they would pay as good a rate of interest as we could reasonably expect. Considering all the facts that I have pointed out, I do not think that we can be surprised that we should have had a considerable diminution in the receipts, and therefore that the rate of interest which we are able to return you on your capital is not quite as large as it was; but though that is so it is still a return not to be despised, and one with which I for one, as a large shareholder, desire to express my own individual satisfaction. If the directors had been able to do anything by which they could have increased it they would have been glad to do so, but the income of the Company is beyond the control of the Board. Having made these observations, I have now to propose "that the report and accounts which have been submitted be received and adopted."

The Hon. Ashley Ponsonby seconded the resolution.

The Chairman, in reply to Mr. Dolman (who asked whether, in view of the somewhat diminished revenue, the directors were prepared to exercise their liberality by foregoing part of their fees) said that personally he did not care what salary he received. He did not get much more than the rest of the directors, and it certainly did not recoup him for the trouble he took in connection with the Company. But, as a matter of principle, it was the very worst thing shareholders could do to pay their directors badly, because, if they did so, they would not get first-class men to attend to their work. In further reply to shareholders, he said the insurance of the steamer was arranged with one of the best insurance offices in London, and the amount depended on the number of days the vessel was out of harbour. The more days it was out the less rebate was received from the insurance. The steamer, buildings, and stores fund stood at £17,024, and, as they would see from the accounts, "this amount was taken from the reserve fund of both Companies, and includes £15,105 5s. 11d., the cost of the steamer, which is in course of repayment by half-yearly instalments, in accordance with the terms of the resolution passed by a special meeting of proprietors on the 10th May, 1870." As to the renewal of the concession nobody could be more gratified than he if it were renewed, but it was impossible to say what would be their position at the end of the concession. They had, however, three advantages. They had a priority of claim over anybody else to carry on the service, and should the worst come to the worst they had been increasing the amount of the reserve fund in order that a considerable portion of the capital might be represented by it, in addition to which they had the value of the cables which belonged to the Company, which would be a considerable amount, as well as the steamer and buildings which were part of the reserves.

The resolution was then put and carried unanimously.

The Chairman next moved, and the Hon. Henry R. Brand, M.P., seconded, "That, in accordance with the recommendation of the Court of Directors, a dividend for the half year ended 30th June, 1884, at the rate of 13 per cent. per annum, less income-tax, upon the capital of the Company, be declared, and that it become payable on and after the 1st September next," which was also carried unanimously.

Sir Julian Goldsmid and the Hon. Ashley Ponsonby, the retiring directors, were re-elected to their seats at the Board. The Company's auditors were also reappointed, and a vote of thanks having been passed to the Chairman, the proceedings terminated.

Eastbourne Electric Light Company.

The general meeting of the above Company took place on Thursday, at the Gildridge Hotel, Eastbourne, under the presidency of Mr. Alderman Boulton, of Torfield. We take the following report of the meeting from the columns of the *Eastbourne Standard* for Saturday last:—

The minutes of the last general meeting and the notice convening the present meeting having been read, the report of the directors, a copy of which had been sent to each shareholder, was taken as read.

The Chairman said the report was so exhaustive and had been so extensively circulated that it left him little to say; nevertheless, there were one or two points to which it might be as well that he should direct their attention. (1) As to the arrangement with the Hammond Company. It would be seen that for the past two years they (the Eastbourne Company) had been working at a loss. Of course that was a mode of business which could not go on long. Rather than attempt to wind up the Company, they decided, in view of the strong opinion expressed by scientists as to the future of electricity, to negotiate with the Hammond Company, with a view to their taking over the working of the Company. It was ultimately agreed that they should take the management for a period of two years, that they should pay all outgoings and charges, and in return receive all rentals and profits which might result from the sale of electricity, while they should bear all the risk in connection with the matter. This the directors considered a very good arrangement. They could not, they felt, be worse off, while by the aid of the new plant which the Hammond Company would put down they might and probably would be in a position at the end of the two years to earn money and pay a dividend. What the directors asked them to do was to be patient a little while longer. He would refer them to the last clause

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but one, which had reference to their determination of the contract with the Town Council for the public lighting. In the starting of all new concerns it was impossible to calculate exactly the cost of supplying a commodity. They (the directors) thought they had made a good contract with the Local Board, but experience had shown them that they were not receiving enough, the light really cost more than they got for it. Acting, therefore, under the advice of Mr. Hammond, they had given notice for the determination of the contract, and at the same time issuing an invitation to the council to confer with them as to amendment of terms, and to see whether, in the face of the public, they would put out the electric light and go back again to gas. Of course, after all, the council was only a representative body, and if the ratepayers desired that they should go on with the existing light, he did not see that they could take any other course than to comply with the request. What they (the directors) were anxious to do was to push the incandescent light in the shops and private houses. Many shops were already lighted with it, and so far as he could ascertain it had given every satisfaction. He inquired the other day of Messrs. Lavis, and they said it answered perfectly, and on no account would they be without it. With this object in view they were endeavouring to secure the services of a good canvasser, and he had no doubt before long the engagement would be completed. They hoped before many weeks were passed to have numerous orders for the incandescent light for shops and private houses. If the council declined to renew their contract, then the machinery could be utilised to supply the incandescent, while, if the parade service should be retained, they would still have machinery sufficient to deal with the increased business. The Company had had no slight difficulties to contend with, a good deal of ill-natured abuse had been levelled at them, while they had been spoken of even by friends in that suggestive way in which friends were sometimes given to speak. They had not, however, been discouraged, but, on the other hand, with the assistance which the Hammond Company would be able to give them, they hoped to achieve success. One point in conclusion he ought to mention, and that was that since the 12th of February, to which date these accounts were audited, they had been able to pay off all, or very nearly all, the liabilities of the Company, with the exception of course of the interest on the debentures. He moved the adoption of the report.

Mr. LANGHAM said it would not be necessary for him to do much more than echo the statements of the chairman. It was scarcely necessary for him to say much about the Hammond Company, because the ratification of that agreement would come before them later on. He should like, however, to refer to one point. It was not merely the fact that they were not earning a dividend—that was often a difficulty with a new company at the outset—but the Electric Lighting Act, although it pretended to give the electric light protection against the gas company, in reality secured to the gas companies an increased monopoly, while it stopped the application of capital for the purposes of electric lighting. This, as a matter of fact, was the way in which the matter had operated as regards the Eastbourne Company, and as he believed it had done with other companies. Their Company had put out one or two notices inviting additional capital, locally, but without success, and that led to their negotiations with Messrs. Hammond and Company and the Anglo-Brush Company. He thought the result had been satisfactory; they had been arranging with those companies to supply them with additional plant, and take all the risk, and to effect that arrangement at a juncture when they (the directors) had a balance in hand to pay off their own liabilities with. He had no doubt the press, who were in a position to arrive at the opinion of the public on the question, would be able to say whether the ratepayers and visitors were in favour of the retention of the light or otherwise, and thus, as the voice of the public, represent that opinion to the council. They (the Company) only asked for the renewal of the contract upon fair terms, and fortunately they had a precedent. At Hastings they shut off the light at eleven o'clock at night, but at all events they (the Eastbourne Company) were prepared to deal with the council here on the same terms as the Hastings Company with their corporation. By way of strengthening that observation he might mention that the council was prepared to respond to their invitations to consider the matter. He believed Mr. Hammond would be willing to come down and go into the whole question carefully. Continuing, the speaker said the Company had almost unsurmountable difficulties to contend with, besides which they were called upon to spend a large sum of money on posts and lamps, which latter, in the case of the gas contracts, had always been found by the local authority. He, however, believed that under the new arrangements the result would be satisfactory to the shareholders, and place the Company in the position of earning in future a substantial dividend. He had much pleasure in seconding the chairman's proposition.

The adoption of the report was unanimously agreed to.

Mr. Routledge having been re-elected as a director, and Mr. Hammond's name having been added to the directorate in place of Mr. Diplock, deceased, the meeting was made special to consider the agreement with the Hammond and Anglo-Brush Companies, by which the management of the Company for two years from 2nd Feb. last, the provision of all necessary service and the payment of all working expenses and charges, including debenture interest, is undertaken by the Hammond Company at their sole risk, the understanding on which this agreement is based being that the Hammond Company shall take all profits as remuneration, and bear all losses should such occur. By the agreement with the Anglo-Brush Company, this Company accept payment by debentures for the plant supplied by them to the Eastbourne Company.

It was unanimously agreed that this agreement should be ratified, and a meeting was fixed for the 18th of the present month for the special purpose.

The proceedings terminated with a vote of thanks to the directors and officers, which was duly acknowledged.

National Telephone Company (Limited).

The report of the directors of this Company for the year ending the 30th of June last states that the annual gross revenue on the 30th of June was £57,271 15s. 2d., against £43,111 5s. 6d. at the end of the previous year, showing an increase of £14,160 9s. 8d. After providing for the accrued interest on the debentures, the usual dividend of 6 per cent. on the preference shares, and having paid a dividend for the first half of the year at the rate of 1 per cent. per annum on the ordinary capital, £6,672 9s. 9d. will remain as the balance of profit. Out of this the directors propose to allot a further sum of £3,375 to the payment of a dividend at the rate of 1½ per cent. per annum on the ordinary capital for the second half of the year, and to carry forward £3,297 9s. 9d. The loss on trunk wires has increased, and for the year amounted to £986 7s. 3d. This large loss has been in some measure due to the protracted negotiations with the Post Office with relation to the new trunk wire agreement, which extended from November, 1882, to April, 1884, when it was settled upon its present basis. The directors desire to acknowledge the general courtesy of the permanent officials of the Post Office Department, and to state that the operations of the Company have been facilitated within the official lines laid down. Each day's experience, however, proves that those lines are so narrow as practically to deprive the public of the major portion of the advantage it is entitled to expect from the telephone.

Cuba Submarine Telegraph Company (Limited).

The half-yearly report of the directors of this Company shows a gross revenue of £19,918, including £594 brought forward. After providing for expenses, and adding £1,266 to the reserve fund, which is thus raised to £58,000, and meeting the interest on the Preference shares, there is a balance of £7,567, out of which it is proposed to pay a dividend on the Ordinary shares at the rate of 9 per cent. per annum, tax free, leaving £367 to be carried over to the accounts of the current half year.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. AUG. 6.		BUSINESS DONE WEEK ENDING AUG. 6. Highest.	Lowest.
Anglo-American	31½,	32½	32	—
Do. Preferred	56½,	57	57	56½
Do. Deferred	7,	7½	—	—
Brazilian Submarine	9⅞,	10⅛	10	9⅞
Cuba	10½,	11	10¾	—
Do. Preference	17,	18	—	—
Direct Spanish	4½,	5	—	—
Do. Preference	14¼,	14¾	—	—
Direct United States Cable	9¾,	10	10	9¾
Eastern Telegraph	11,	11¼	11 3-16	10⅞
Do. 6 per Cent. Preference	13¼,	13¾	—	—
Do. 5 per Cent. Debentures, 1899	102,	106	103½	—
Eastern Extension	11⅜,	11⅝	11⅝	11 3-16
German Union	9,	9½	—	—
Globe Telegraph and Trust	6⅝,	6⅞	6 15-16	6¾
Do. Preference	12½,	12¾	12 11-16	12 7-16
Great Northern	13½,	13¾	13 11-16	—
Indo-European	31,	32	—	—
Reuter's	8,	8½	—	—
Submarine	162,	167	164	—
West India and Panama	⅞,	1⅛	13-16	—
Do. 1st Preference	6¾,	7½	6⅞	—
Western Brazilian	5⅝,	5⅞	5¾	5½
Western Union 7 per Cent. 1st Mortgage	123,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	106	103	—

TELEPHONES.

Consolid. Telephone and Maintenance	3-16,	5-16	—	—
Oriental	⅛,	⅜	—	—
United Telephone	10½,	11	10⅞	10

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1¾,	2	—	—
Do. (fully paid)	3½,	4	—	—
Hammond Light (£3 15s. paid)	⅜,	⅝	—	—
Swan	⅛,	⅜	—	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	32,	33	32⅞	32¼
India Rubber, Gutta Percha, and Telegraph Works	22,	23	22¾	22⅝

TRAFFIC RECEIPTS FOR JULY, 1884.

COMPANIES.	July, 1884.	July, 1883.	Increase.	Decrease.
Cuba Submarine	3,200	2,755	445	—
Direct Spanish Telegraph	1,492	1,376	116	—
Eastern Extension	36,770	37,177	—	407
Great Northern	26,360	—	—	—
West Coast of America	4,525	—	—	—

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NOTES.

ELECTRIC LIGHTING IN A GASWORKS.—A French paper says that Pilsen arc lamps are used to light the Municipal Gasworks at Prague.

ELECTRIC LIGHTING IN AMERICA.—The United States Electric Light Company are fitting up a central station at Portland, Oregon.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 8th August were £2,398.

COPPER.—The total production of copper in Arizona State this year is expected to be nearly 50 per cent. greater than last year's yield, which amounted to 17,000,000 pounds.

SAFETY LAMPS.—It is said that the Viennese fire brigade have been supplied with electric lamps to enable them to enter rooms where gas is escaping without incurring the risk of an explosion.

GULCHER ELECTRIC LIGHT COMPANY.—The petition for the reduction of this company's capital from £300,000 to £150,000 is to be heard before Mr. Justice Pearson on the 20th inst.

AN ELECTRIC EEL.—A large *gymnotus electricus*, said to be nearly six feet long, is to be seen in the Zoological Society's Gardens at the present time. It has recently arrived from South America.

DEVON AND CORNWALL ELECTRIC LIGHT COMPANY.—The creditors of this company should send their names and claims to Mr. H. T. Edwards, 66, Coleman-street, E.C., on or before the 1st October.

BOOK RECEIVED.—"The Electrician's Pocket-Book," by E. Hospitalier, translated from the French, with additions, by Gordon Wigan, M.A. Published by Cassell and Co., London, Paris, and New York.

ELECTRIC LIGHTING IN MILLS.—The mill of Messrs. Pia and Co., at Brandizzo, Italy, is lighted by 85 Edison lamps. The installation has been carried out by the Societa Generale Italiana di Electricita.

TELEGRAPH RECEIPTS.—The receipts from the Postal Telegraphs from 1st April to 9th August were £595,000, against £590,000 in the same period of last year. The estimate for the year 1884-5 is £1,800,000.

THE NEW ATLANTIC CABLES.—The cable ship "Faraday" picked up and spliced the shore end of the second Bennett-Mackay cable on Wednesday. The laying of it is proceeding satisfactorily, the weather being very fine.

ELECTRIC LIGHTING FOR WAR PURPOSES.—Similar experiments to those recently carried out at Aldershot with Sautter, Lemonnier and Co.'s portable electric light apparatus have just been conducted at Berlin by the German staff.

TELEGRAPH INSTRUMENTS IN FRANCE.—*L'Electricité* says that there are at the present time 7,702 Morse instruments at work in France. The Bandot apparatus which works between Paris and Marseilles transmits on the average 1,800 messages per diem.

ACCIDENT FROM LIGHTNING IN SWITZERLAND.—During a recent storm a house in the village of Villard-Lurin, near Brides-les-Bains, was struck by lightning and set on fire. The conflagration spread rapidly, and ninety houses were attacked by the flames.

TENDERS WANTED FOR LIGHTING.—The Walthamstow Local Board want tenders for lighting their district by oil or otherwise. Tenders are to be sent in by the 21st instant. Specifications can be obtained of the Surveyor, at the Town Hall, Walthamstow.

NEW METEOROLOGICAL OBSERVATORY.—Lord Mount-Edgcumbe laid the foundation-stone of a new meteorological observatory at Falmouth on Tuesday. Magnetic observations will also be taken, the instruments for that purpose being supplied by the Royal Society.

ELECTRIC LIGHTING IN BERLIN.—The central station of the Edison Company in Berlin is nearly finished. It will contain four 500-light Edison dynamos, and the necessary boilers and engines for driving them. This gives the station a capacity for lighting 2,000 sixteen candle-power lamps.

ELECTRIC PROPULSION OF BALLOONS.—A very successful trial was made in France a few days since by Captain Renard, of the Engineers, with a balloon steered and to a certain extent propelled by a kind of screw actuated by an electric motor. At present we have no details of the apparatus used.

ELECTRIC MOTORS FOR TRAMWAYS.—An American paper says:—"A successful experiment in the application of electric motors to street railways is reported to have been made by the East Cleveland, Ohio, Railroad Company, July 26. The company was sufficiently satisfied to contemplate the extension of electricity to their whole service."

THE TELEPHONE AND THE POST OFFICE.—We give this week a report of the discussion which took place a few days since in the House of Commons on the policy of the Post Office with regard to the telephone companies. It will be found interesting reading. We have discussed the whole matter in our leading article this week.

BUSINESS NOTICE.—We are informed that Messrs. Shaw and Connolly, of Manchester, have finally removed their offices from 10A, Victoria-buildings, to their works in Alexandra-street, Oldham-road, Manchester, having made the necessary additions to meet the extra accommodation required. They are also adding considerably to their plant.

THE GASLIGHT AND COKE COMPANY.—The receipts of this company for the half year ended June 30 last reached £1,552,644. At the half-yearly meeting, held last week, it was resolved to declare a 12 per cent. dividend, and carry forward £188,929. Last year they paid 11 per cent. Surely they can afford to reduce the price of their gas again.

ELECTRIC LIGHTING EXHIBITION AT BRUSSELS.—The committee of organisation in connection with this exhibition, which it is proposed to hold next year, have met to consider the necessary details for its promotion. Sub-committees have been appointed to choose a site, to organise the exhibits of electric lighting apparatus, and those devoted to heating and lighting by gas.

GRAVESEND.—At a meeting of the corporation on Wednesday the town clerk announced that the Board of Trade had revoked the provisional order granted some time since to the Brush Company, owing to the company not having executed the work within the time allowed them by the order. The corporation are now free to recommend the granting of the required powers to another company.

ELECTRIC LIGHTING AND GAS.—One of the first gasworks erected in the North of England was that put up to supply gas to Messrs. Duff and Rowntree's establishment at Bishop Auckland, nearly fifty years ago. The same firm were among

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the first, if not the first, to adopt the electric light, and the electrical plant now stands within a few feet of the gasmaking apparatus which it is doing its best to elbow out of its place.

BRIGHTON ELECTRIC RAILWAY.—Mr. Magnus Volk's electric railway seems to be as popular as ever to judge from the number of passengers it carries. He has fitted up some Maxim incandescent lamps to light his Aquarium Station. We are surprised that other sea-side resorts do not imitate Brighton in this matter. There are dozens of places where such a line would prove useful and might be made to pay well also.

PROVINCIAL BRUSH COMPANY.—A notice in the *Gazette* says:—"A petition for confirming a resolution reducing the subscribed capital of the above company from £99,205 to £54,562 15s., making the total capital £155,357 15s., was, on the 10th July, 1884, presented to the High Court of Justice, Chancery Division, and is now pending; and the list of creditors of the company is to be made out as for the 30th August, 1884."

A WANTON ACT.—Some of the inhabitants of South Uist, Scotland, have lately been committing themselves to some foolish and wanton acts of destruction to show their hatred of landlords. Amongst other things, they cut down the telegraph wires near the village, and twisted them across the road, in the hope of upsetting vehicles or horsemen. It appears that this is the second time within a very short period that this has occurred. Verily political passion indulges in strange freaks.

POSTAL TELEGRAPHS.—The competitive examination for the vacant appointment of technical officer in the engineer-in-chief's department has resulted in the success of Mr. Hartnell, of Nottingham. The following gentlemen also competed at the examination, and obtained positions in the order named, viz.:—Messrs. Slingo, Stubbs, Hinton, Moon, Probert, Morgan, and Ferguson. Mr. Hartnell, it may be remembered, obtained the highest number of marks in last year's technological examination in connection with the City and Guilds' Institute.

TELEGRAPHIC COMMUNICATION IN SOUTH AFRICA.—The Free State and Transvaal capitals were expected, says *The Colonies and India*, to be in telegraphic communication before the end of August. The fact is not without some significance that the Transvaal Government have deliberately neglected to re-establish the broken line of telegraphic communication with Natal. The circuit will be *viâ* Winburg, Cronstadt, Heilbron, the Coal Fields, thence to Heidelberg, and on to Pretoria. The line from Heilbron to the Coal Fields has been finished, and is only awaiting the junction with the Free State line.

EARTHQUAKE IN ITALY.—A telegram from Rome, dated August 7, states that an earthquake shock occurred on the morning of that date at 2 a.m., and was followed by another at 3:15 a.m. The direction taken by the wave was through Velletri, Nemi, Ariccia, Albano, Castel Gandolfo, and Rocca di Papa and Frascati. The shocks were most severely felt at Rocca di Papa, but no damage was done beyond the felling of two chimneys at Ariccia. At half-past three a severe shock, quickly followed by another, was distinctly felt at Rome, and that which shook the Alban hills extended also as far as Porto d'Anzio, on the coast.

PEROXIDE OF LEAD CELLS.—Mr. F. Maxwell-Lyte writes to us, pointing out that the lead peroxide mentioned in *The Electrician* of 26th ult. as used in the De la Rive battery must be prepared by the usual process of acting by means of nitric acid on the red lead of commerce. A far less expensive method, patented by Mr. Maxwell-Lyte, consists of adding to lead chloride dissolved in hot water a sufficiency of bleach solution and the right proportion of calcium hydrate. By this means lead peroxide of from 90 to 100% may be produced and sold, with a fair margin of profit, at about 3½d. per lb. This could not contain the nitric acid complained of.

TRAIN LIGHTING.—A trial of incandescent lighting is now being made on the London and North Western line. A locomotive running one of the trains between Liverpool and Manchester has been fitted with a Brotherhood engine and a dynamo, the latter supplying the requisite current to a Swan lamp in each of the compartments of the train. A duplicate lamp is also provided and so arranged that it would be switched into the circuit directly the other lamp went out. The current is regulated by a switch from the footplate, a pilot lamp indicating to the driver the candle-power at which the lights are burning. We heard some time since that Mr. Webb was making experiments in this direction, and trust that the results will be satisfactory.

TESTING ALLOYS.—"The possibility of ascertaining the standard fineness of alloys by the aid of electricity," says Professor Chandler Roberts, F.R.S., in his Cantor lectures now being published in the *Journal* of the Society of Arts, "long ago occupied the attention of physicists. In 1823 Becquerel suggested that trustworthy indications might be afforded by the electromotive force developed when the alloy to be tested is placed in an exciting fluid together with an alloy of known composition. The subject was partially investigated by Œrsted in 1828, and its practical importance was further pointed out by Gay-Lussac in 1830. In 1878 the use of magnetic induction for indicating the composition of alloys was suggested by Professor Hughes, who showed incidentally that the induction balance affords a ready means for detecting counterfeits, and I have elsewhere pointed out the degree of accuracy of which this instrument is susceptible."

TELEGRAPHIC COMMUNICATION WITH MAURITIUS.—A curious illustration of the isolation of the Island of Mauritius from the rest of the world by reason of the non-existence of telegraphic communication with that colony, reference to which was made in our leading article of last week, appears in the following paragraph taken from the *Standard*:—"In connection with the stoppage of the Oriental Bank some curious questions have arisen. The bank had a branch in the Mauritius, with which island there is no telegraphic communication. The winding-up petition was presented on May 3rd, and between that date and the 14th, when the news reached the colony, moneys were paid in to the branch, and bills drawn to the amount of three hundred and forty thousand pounds. The legal questions involved were mentioned in Mr. Justice Chitty's court on Saturday, and the decision was postponed until after the Long Vacation."

OVERHEAD WIRES.—At the last meeting of the St. George's (Hanover-square) Vestry, Sir A. Hobhouse moved that Her Majesty's Government be requested to bring the erection and maintenance of overhead wires under due control by some adequate local authority, a resolution which was passed after some discussion as to the words "adequate local authority," which it was thought were too vague. The St. James's Vestry (Westminster) having written to the Local Government Board asking that a law should be passed giving local authorities some power over the erection of wires, have received a reply stating that it would be impossible to deal with the subject by legislation this Session, and the Govern-

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ment cannot now say what Bills they will introduce next year, but there would probably be an advantage if a select committee were appointed to inquire into the subject, and that the Board would consider whether steps should be taken early next year with this view.

Electric Lighting at Craig-y-Nos Castle.—The electric light has been introduced into Craig-y-Nos Castle, the Welsh residence of Madame Adelina Patti, by Messrs. Paterson and Cooper, and their agent, Mr. John Legg, of Swansea. The installation consists of 70 twenty candle-power incandescent lamps, distributed in the winter garden, conservatory, dining hall, drawing room, billiard room, boudoir, &c. In the winter garden and conservatory the lamps hang by twisted silk cord from the roof, and have tinted green lilies over them. The effect amongst the various climbing and other plants which are festooned about the roof is charming. In the dining, drawing, and billiard rooms and the boudoir the lamps are partly attached to the existing gas fittings and partly hung by silk cords from the ceilings. The lamps are all covered by tinted opalescent ruby and other shades. The lamps are worked by one of Paterson and Cooper's phœnix compound shuntwound dynamos, driven by one of Crossley Brothers "Otto" gas engines.

Arc Spectra.—In a recent number of *The Chemical News* Mr. Hartley stated that the short lines in some arc spectra are lengthened by moistening the electrodes with water; and, moreover, it is suggested that this phenomenon is due to the cooling action of the water on the negative electrode, since heating the electrodes produces a reverse result. Herr Wiedemann takes exception to this explanation, and has offered the following in its place, the pith of which is given in the Chemical Society's *Journal* for this month :—"When the electrodes are moistened, the discharge produces oxygen and hydrogen gases, which re-combine at some distance from the electrode with great development of heat, consequently increasing the temperature of the metallic vapours, and also the length of the lines. By directly heating the electrodes, however, the potential available for the production of spark is lowered, with the result that the amount of matter dispersed at each discharge is diminished, as well as the temperature of the spark, the ultimate effect being shortened lines in the spectrum."

Magnetism.—M. Duter presented the following note to the French Academy of Sciences at a recent meeting. With tempered steel plates 1mm. thick and varying in diameter from ·040m. to ·005m. he formed cylindrical piles; in some of these piles the plates were directly in contact, in others they were separated by strips of pasteboard the thickness of which varied from extreme thinness up to ·001m. The piles were placed in the centre of a very powerful magnetic field, and after having been withdrawn, were found to constitute perfectly regular permanent magnets. The closer the contact between the plates the greater was the carrying power of these magnets. In a pile of 100 plates directly in contact and pressed close together in a brass cylinder, the carrying power at each end was 30 grammes. This result obtained, he took down the plates one by one, taking care to mark the upper and lower faces of each one. Each of the plates retained in this condition but little magnetism. Each, however, constituted a flat magnet, the two faces of which formed the poles. For, on re-forming the pile, it again formed a perfectly regular magnet, but was weaker than at first.

The Telephone in Aberdeen.—We have received the latest edition of the list of subscribers to the Aberdeen Exchange of the National Telephone Company, which has been brought up to date. The first telephone was set up in Aberdeen in 1881; at the present time there are 400 instruments at work there. The number of connections with the exchange is 355, and there are 20 private lines, the two together representing nearly 230 miles of wire. The longest line is that to Culter Paper Mills, which measures 8¼ miles. The exchange is in telephonic communication with the police and fire station, whence also telephone lines run to the firemen's houses, so that on an alarm being given the men can be summoned with the least possible delay. The company also offer to establish automatic fire and burglar alarms in subscribers' houses, by means of which the police or fire brigade can be at once apprised of fire or burglary. It should be mentioned that the exchange is open day and night, Sunday included. The list is divided into various heads ; first we have the subscribers' names in the order of their exchange numbers; then a similar list arranged alphabetically; then a list in which the subscribers are classified under their various trades and professions. The list is extremely well got up, and has been neatly printed by Messrs. John Avery and Co., of Aberdeen, who are well deserving of a word of praise. We notice that the Exchange is still under the able management of Mr. J. D. Miller.

Reducing Bromide of Silver Residues.—M. Scola communicates to the *Bulletin* of the French Photographic Society an easy method of reducing waste bromide of silver to the metallic state, and not only obtaining the bromide in a useful form, but also generating an electric current at the same time. To separate the bromide of silver from the waste emulsion, M. Scola recommends that two or three per cent. of sulphuric acid should be added, and the mixture should be boiled for some minutes, after which the bromide settles rapidly to the bottom of the vessel. It is now washed and dried, when it is ready to be cast into sticks for use in the battery about to be described. The battery in which the reduction is effected is constructed on precisely the same principles as the chloride of silver battery of Warren de la Rue, and one form of this, as is well known, consists of a rod of amalgamated zinc immersed in acidulated water, and opposed to a similar rod of fused chloride of silver, a platinum wire being embedded in this latter to serve as a conducting terminal. When the plates of the battery are connected by a conducting circuit the chloride of silver becomes reduced to the condition of metallic silver, while the chlorine unites with some of the zinc to form chloride of zinc. If the negative plate of the battery is made of fused bromide of silver, reduction takes place quite readily when the terminals are united ; and when the battery is exhausted it is merely necessary to fuse the resulting spongy silver in order to obtain it in a convenient condition for use in making a fresh supply of nitrate, while the whole of the bromine takes the form of bromide of zinc, and remains in solution.

The Theory of Magnetism.—Professor A. K. Eaton writes in the *Electrical World* for July 26 :—Allow me to correct a misapprehension on the part of Professor Hughes as to the scope of the statement quoted from Faraday, in the article reproduced in your last number. The statement is as follows—"Faraday remarked that the magnetic qualities of iron disappeared at yellow-red heat (1050° C.), reappearing gradually when cooled to red-heat (700°C.)." *Vide Electrician*, p. 430, Vol. XII. Professor Hughes adds that he has found that "if we heat steel to yellow-red the whole previous structure disappears and does not reappear on cooling." He is quite right

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in this, but has entirely misapprehended the meaning of Faraday's words. Faraday did not mean that a magnet having lost its magnetism by heating to a yellow-red would recover its magnetic character by cooling to a red heat. What he meant was that a piece of iron which, when cool was attracted by a magnet, ceased to be at all attracted when raised to a yellow-red heat, but would again be, in a measure, attracted when cooled to a red-heat. Many years since, wishing to determine the effect of tempering steel while the magnetic current was circulating through it, I heated the steel to a cherry-red, and taking it up by the poles of a strong horseshoe magnet immersed it in water while in this magnetic condition. In this way I obtained unusual magnetic intensity in the bar of steel. But on one occasion, having raised the steel to a yellow heat, I found that my horseshoe magnet would no longer lift the bar, and it was necessary to wait until it became cooler. Briefly, then, any piece of iron or steel when heated to a yellow-red becomes insensible to the action of a magnet, but becomes capable of magnetisation again when cooled down.

THE ELECTROLYSIS OF SOLID GLASS.—Herr Warburg has made some experiments in this direction, the results of which he has communicated to *Wiedemann's Annalen*. We take the following summary of his paper from the *Phil. Mag.* for August:—"In the electrolysis of lime-soda glass, heated to about 300° between mercury electrodes, a badly conducting layer of silicic acid is formed on the anode side of the glass, which soon reduces the strength of current to a fraction of its original value. This layer has a greater or less thickness, according as a greater or lesser electromotive force has acted in the circuit in a definite time. It is visible, showing the colours of thin plates, diminishes the surface-conductivity of the glass in the cold to a fraction of its original amount; and at a high temperature, when the mass of the glass has become a conductor, it acts like the dielectric of a condenser, whose coatings are the conducting mass of the glass, and the mercury of the anode. The capacity of this condenser was found to be independent of the difference of potentials of the coatings, between 1 and 20 Bunsen's elements, and for a square centimetre of the glass used it varied from ·021 to ·041 microfarad, according as the layer was formed by 30 or 15 Bunsen's elements acting for several hours at 300°. The formation of this layer may be avoided by using sodium amalgam as anode; the result of the electrolysis may then be quantitatively determined. In this a quantity of sodium is given off at the cathode and absorbed at the anode, so that the weight of the glass does not vary; the weight of the sodium is chemically equivalent to the silver which is deposited at the same time in the silver voltameter. During electrolysis the glass remains perfectly clear, and it was found that all the properties of the glass were not appreciably altered by electrolysis."

EARTHQUAKE IN AMERICA.—A Reuter's telegram, dated New York, Aug. 10, says:—"At two o'clock this afternoon a shock of earthquake passed along the Atlantic coast, from Philadelphia to Portland. It lasted about ten seconds, and was distinctly perceptible in New York and the district." *The Times'* Philadelphia correspondent, telegraphing from that city on the 11th, says:—"The earthquake yesterday suddenly moved along the Alleghany Mountains and their eastern slopes, from Virginia to Vermont, in a direction from south-west towards north-east, extending over the entire country from the mountains to the ocean. The most southerly city in which the shocks were noticed was Washington, and the most northerly Brattleborough, Vermont. Two distinct shocks, each of about two seconds' duration, with an interval of about four seconds, were generally felt, while in New York and further eastwards a slight third shock was experienced a few minutes afterwards. The earthquake was observed at nine minutes past two o'clock in the afternoon at Philadelphia, and somewhat later to the eastward of this city. It was most severe in New York city, Connecticut, and Boston. The vibration was slighter elsewhere. No loss of life was caused, except that one convict was frightened to death in Hartford Gaol." The *Daily News* New York correspondent says that the shock was most severely felt at Hartford, Connecticut. He also states that it is reported from Boston that six distinct shocks were felt there. He gives the duration of the earthquake wave as from 10 to 15 seconds. *The Standard's* New York correspondent states that the shock was first felt in New York at seven minutes past two, and that the vibration continued for 20 seconds; in other respects he corroborates the other correspondents. Later information says that the shock was felt seven miles out at sea from Sandy Hook, and that another slight shock was felt in New England and at Long Island on the 11th instant.

THE INVENTIONS EXHIBITION.—The classes into which the exhibits are to be gathered together at South Kensington next year in the buildings now occupied by the "Healtheries" have been arranged. Electrical machinery and apparatus is to be classified as follows:—Class 66. Generators.—Dynamos, primary and secondary batteries, thermo-electric batteries. Class 67. Conductors.—Submarine cables and apparatus for laying them, aerial wires, and underground cables, insulators and poles, insulating and coating materials, joints and connections, underground conduits, pipes, tubes, troughs, &c., electric light leads. Class 68. Testing and measuring apparatus.—Galvanometers, magnetometers, dynamometers, voltmeters, current-meters, methods of testing. Class 69. Telegraphic and telephonic apparatus.—Needle instruments, A B C instruments, Morse instruments, type-printers, relays, duplex and quadruplex apparatus, keys, recording instruments, automatic transmitters, electric bells, indicators, telephones, microphones, lightning protectors. Class 70. Electric lighting apparatus.—Lamps, resistance coils, cut-outs, safety catches, switches, fittings for glow and other lamps. Class 71. Electro-metallurgy and electro-chemistry.—Methods of depositing and coating various metals, electrotyping, galvano-plasty, vats, cleaning and polishing apparatus, materials, tools, and appliances. Class 72. Distribution and utilisation of power.—Electric railways, electric motors, electrically-driven boats, tricycles, and other conveyances, systems of distribution. Class 73. Electric signalling.—Fire and burglar alarms, railway, ship, and time signals, water level and wind indicators, tell-tales, electric clocks, chronoscopes, &c. Class 74. Lightning conductors. Class 75. Electro-medical apparatus. Class 76. Electrolytic methods for extracting and purifying metals.—Copper, zinc, lead, iron, refining the precious metals. Class 77. Electro-thermic apparatus.—Electrical apparatus for war, mining, blasting, and other purposes.

A WHALE CAUGHT BY A CABLE.—Mr. Robinson Kendal, chairman of the West Coast of America Telegraph Company, has communicated the following extracts from letters received from that company's officials on the west coast of South America to the papers. The captain of the company's repairing steamer writes:—"Having picked up 21 knots of cable, and while continuing picking up, an immense whale came up to the bows entangled in the cable. It seemed to be about 70ft. in length. In its struggles to get free the cable cut right into its side, the

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whole of its entrails coming out, and great streams of blood. In its last dying struggle it parted the cable on the bow sheaves and floated to windward of the steamer. The cable was twisted up in the form of a wire rope for about two fathoms, and in six different parts it had the appearance of having been bitten through sufficiently to stop all communication. There is no doubt the whale has been the cause of the interruption." Their manager also writes:—"The cause of the breakage of the cable, as has been pointed out to you in Captain Morton's report, was a huge whale, which became entangled in the turns of the cable, and was held prisoner for seven days; the interruption was unfortunate, but it is, at least, satisfactory to know that the cable did not give way naturally, and that where picked up, the sheathing, yarn, and core were found to be in an almost perfect state of preservation, in fact, looked as good as on the day the cable was first laid." Mr. Kendal gives no dates, but the facts, as related, are interesting to cablemen. It is satisfactory to find that the cable is fully up to such a heavy strain as was put upon it, and also to have another instance of careful fault-finding and rapid repairing. Shareholders in cable companies well know that the quicker a fault is found and repaired the less money it costs, and the less the traffic is impeded. The India Rubber, Gutta Percha, and Telegraph Works Company are also to be congratulated upon the excellence of their work, they having laid the whole of the cables for the West Coast Company. This little incident shows the wonderful strides that have been made in cable making and repairing of late years.

THE LARTIGUE ELECTRIC RAILWAY.—A model of this railway is now to be seen at the Rouen Exhibition. It is a single rail line, with supports in the shape of an Λ. The carriages are of wicker work, with metal framework. They weigh about 1,600 kilograms each, and can carry eight persons, four on each side, sitting back to back. The train at Rouen, says *L'Electricien*, consists of three carriages and the motor. On the latter is a Siemens dynamo, type D^3, which is used as the motor. The current is produced by a D^2 Siemens series machine. This makes 1,400 revolutions per minute, and is connected to the non-insulated rail of the Λ-shaped supports, and to a return. The current is taken off the rail by laterally placed rollers, which also assist in preserving the balance of the carriages. The motor makes 1,000 revolutions per minute. This speed is reduced to 125 by gearing. The total resistance of the circuit, comprising the generator, conductors, permanent way, and motor is 1·5 ohm; that of the conductors and the permanent way is less than ·1 ohm. By the aid of commutators on the motor it is possible to run the train backwards or forwards. Resistances gradually introduced into the circuit enable the speed to be slackened as required. The permanent way at Rouen is in the form of a closed ring, 111 meters long, and with very sharp curves and gradients. The whole distance is traversed twice in two minutes. The change made is ·15 fc. per person, and the railway is fairly popular. M. Boistel has published the following data. A train, composed of three carriages and a motor, weighs when empty 2,400kg. Taking the weight of each traveller as 45kg., the total reaches 3,480kg. The speed is 1·30m. per second. At starting the E.M.F. of the generator was 165·5 volts, that of the motor 105·7 volts, and the current 48 amperes. The electrical work absorbed was therefore 7,944 watts, or 10·8 horse-power. The work utilised was 5,073 watts, or 6·9 horse-power. The electrical return was therefore 63·8 per cent. In normal working the E.M.F. of the generator was 139·9 volts, that of the motor 98·4 volts, and the current 22·35 amperes. The electrical work expended was therefore 3089 watts, or 4·2 horse-power. The work utilised was very nearly 3 horse-power, and the electrical return was therefore about 71 per cent. There were no experiments made with a brake to determine the mechanical work and duty, but there is every reason to suppose, says our contemporary, that in the two cases above mentioned the mechanical duties were respectively 50 and 57 per cent.

UNDERGROUND WIRES FOR NEW YORK.—In the last number of the *Operator* Mr. G. M. Coggeshall discusses the subject of overhead and underground wires in New York. He concludes as follows:—"We will now discuss the various kinds of conductors needed for the different systems. The telephone, being the most easily affected by induction and requiring connections at every building, necessitates the use of separate insulated conductors. The various automatic systems and the messenger service require the same. The telegraph companies, owing to the long distance between offices, could use any of the cable systems, allowing one or more to each company. For the electric light some sectional system of large conductors is necessary, preferably those wound with cotton dipped in compounds of wax, resin, &c., and encased in lead. The use of conductors encased in iron pipes would not be advisable. The selection of insulated conductors and the construction of conduits are matters that our electricians and engineers are fully competent to determine. Having decided upon a feasible plan, we will next arrange for the construction and management of the conduit. Evidently it would not do for a private corporation to build or manage it, therefore the electric companies should organise a separate company managed by a Board of Directors chosen from each company, the stock to be equitably divided among the various companies, the underground company to make all connections, repairs, tests, &c., and do all work connected with its department. As to the cost of such an undertaking, from actual experiments made recently in Boston, and from careful approximate calculations made here in New York, a system such as we have mentioned, for the down-town district, would cost about 1,500,000 dollars per square mile; the residence section would cost about 1,000,000 dollars per square mile, meeting all the present and prospective wants of all the electric companies. The people who are served are asking too much when they demand that all wires shall go underground. This is probably the dividing line between the people and the electric companies. As an illustration of what I mean I would say that the heaviest business carried on by telephone is between the various commercial houses and exchanges, and the railroad, steamboat and steamship docks, and yet the telephone company get for this the rent from only one, or at the most two instruments on each dock. The cost of putting conductors under ground to these distant points would be immense. The same objections hold good for all the outlying residence and manufacturing sections. It will apply equally to the messenger service and to the electric light companies. The just and proper thing to do is to let this unreasonable cry, "The wires must all come down," cease, and cause to be placed one or two conduits through from the battery to the Harlem River for all the trunk lines. That would do away with all the heavy poles and the bulk of all the wires. Then put the wires in the business and dense residence section underground. A committee could be appointed composed of representatives of the city and the electric companies to decide upon the boundaries of the districts. Other sections to be placed underground as fast as the business warrants it. The foregoing, of course, would require intelligent and careful legislation."

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THE ELEMENTS OF ELECTRIC LIGHT ENGINEERING.

BY E. C. RIMINGTON AND C. W. J. CRAWLEY.

(CONTINUED FROM PAGE 295.)

As the accuracy of Ayrton and Perry's ordinary ammeters and voltmeters depends on the permanent horse-shoe magnet retaining its power, it is important that the keeper should never be left off for longer than necessary. On the other hand, if by accident the instrument be used with the keeper

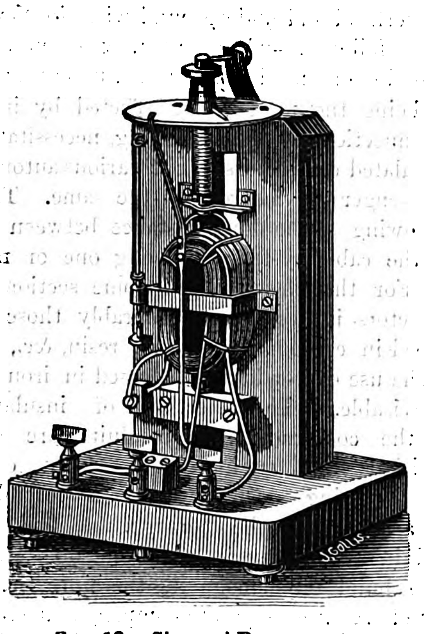

FIG. 12.—Siemens' Dynamometer.

on, the needle is liable to be injured by being swung violently against the side. In most cases it is inadvisable to leave the current running through the instruments when not in actual use for fear of heating the wires. A make and break key is therefore generally introduced into the voltmeter circuit, and only depressed when a reading is required. The ammeter is usually either cut out or short circuited.

Another convenient current-measurer is the Siemens electro-dynamometer, Figs. 12 and 13. Here the coils act, not on a

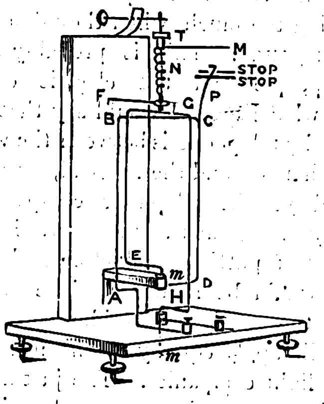

FIG. 13.—Diagram of Siemens' Dynamometer.

magnetised needle, but on a suspended coil, through which, as well as through the fixed coil, the current passes, thus obviating the variation due to loss of magnetism, to which most instruments are liable. Fig. 13 gives the arrangement of the instrument, only one turn of the fixed coil being shown for the sake of simplicity. The current enters at the left-hand terminal, passes through the fixed coil A B C D to the upper mercury cup m', thence through the swinging coil E F G H to the lower mercury cup m, and out at the right-hand terminal. Then since the current in G H is parallel to and in the same direction as that in C D, there will be attraction between G H and C D, and the latter being fixed, G H will move towards it, and the pointer P will turn towards the right-hand stop. It will easily be seen that the currents in all the other parts of the coils have a like effect in making the pointer move to the right.

If the current be reversed, P will still turn to the right-hand stop, for the currents in G H and C D are still parallel and in like direction. This instrument therefore gives no indication of the direction of the current, as is done by instruments with a magnetised needle; but, on the other hand, it can, for the same reason, measure an alternating current, which no instrument with a magnetised needle can do.

Fig. 12 shows an instrument with two fixed coils; one consisting of a few turns of thick wire starting from one terminal, the other having more turns of finer wire, for small currents, starting from terminal No. 3, the other end of each wire being connected to the upper mercury cup, so that whichever fixed coil is employed the current passes through the hanging coil and out by the centre terminal, which is common to both. The current is measured, not by the angle of deflection of the swinging coil, but by the amount of torsion which has to be put on the coiled spring N (one end of which is attached to the hanging coil, the other being fixed to the milled head T) to exactly counterbalance the effect of the current and bring the coil back to its original position, as shown by the pointer P returning to zero. The current is then proportional to the square root of the angle of torsion.

The force of attraction between two parallel wires traversed by the same current varies as the square of the current when the distance between them remains constant. Conversely the current varies as the square root of the attractive force. Now, the force of torsion varies as the angle of torsion; when, therefore, the attractive force due to the current and the opposing force of torsion are exactly equal, the current varies as the square root of the angle of torsion.

The current is therefore equal to the $\sqrt{\text{angle of torsion}}$ multiplied by a constant. This constant is given at the head of the table supplied with each instrument, the table itself being the product of the constant into $\sqrt{5}$, $\sqrt{10}$, $\sqrt{15}$, &c. —that is, the number of amperes corresponding to 5°, 10°, 15°, &c., of torsion as shown by the pointer on the top of the dial.

The constant should be verified occasionally by passing a current of known strength, C amperes, through the instrument, noting the angle of torsion D° ; then the constant $K = \frac{C}{\sqrt{D^\circ}}$.

Should the table be lost or K be found to differ, a new one should be made of the values of $K\sqrt{5}$, $K\sqrt{10}$, $K\sqrt{15}$, &c. Or a table may be worked out for the values of $\frac{C^2}{K^2}$, where C = 1 ampere, C = 2 amperes, and so on; thus giving the number of degrees corresponding to 1, 2, 3, &c., amperes. To use the instrument, it is first levelled by the three levelling screws, till the point of the plumb wire hangs exactly over the fixed point. If there is no plumb wire on the instrument an ordinary spirit level can be used, or for rough work the position of the ends of the moving coil in the mercury cups can be used as a guide, the instrument being altered by means of the screws until each end of the coil is exactly in the centre of its mercury cup. At the back of the base board will be found a milled headed screw working through a brass spring plate. This must be screwed down to free the moving coil.

(*Be careful always to release the spring again* by unscrewing the milled head before moving the instrument or when it is not in use.)

The pointer P should now swing freely between the two stops shown, the point which is bent over being just clear of the surface of the dial. If it is too high or too low it should be adjusted by carefully turning the milled head, on which the suspending fibre is wound. Pointer M (Fig. 14) is now set to zero by the milled head T, when, if the instrument is properly levelled and in order the end of the pointer P will also swing to zero. The instrument is now put in the main circuit and the current turned on, the pointer P immediately swings

over to the right-hand stop and remains there. The pointer M is now turned by means of the milled head T in the direction of the hands of a watch until the needle again returns to zero. The angle of torsion as shown by M on the scale is now looked out in the table where the current equivalent to it is found. If the current is not quite steady the needle P, of course, cannot quite be brought to rest at zero, but must be made to swing evenly on each side of it. Being now enabled to take measurements, and E.M.F. at the terminals, it is advisable to draw a characteristic curve for the dynamo employed, *i.e.*, a curve giving the relations between the total E.M.F. and the current.

The machine is run at a constant speed through a certain external resistance, the terminal E.M.F. and current are observed and noted down, the external resistance is then changed, the speed being maintained the same as before, and

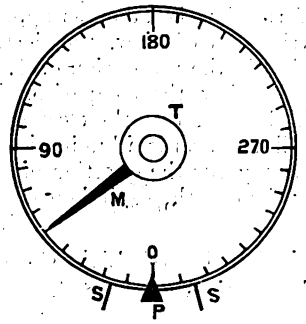

Fig. 14.—Siemens' Dynamometer Dial.

the terminal E.M.F. and current again noted down. About twenty or more observations are made in this manner, the external resistance being varied gradually from being so great that hardly any current is generated by the machine to being so small that the greatest current consistent with safety, as regards the heating of the wire on the armature and field-magnets, is produced. With each variation of the resistance the terminal E.M.F. and current are carefully noted down, the speed being constant throughout. Two lines O X and O Y (Fig. 15) are then drawn at right angles of one another. O Y is divided into a number of equal parts representing volts; O X into a number of divisions on the same scale representing amperes. Next draw a line O D so that tan D O X or $\frac{DX}{OX}$ equals the internal resistance of the dynamo in ohms. Now mark off O m on O X, the number of divisions

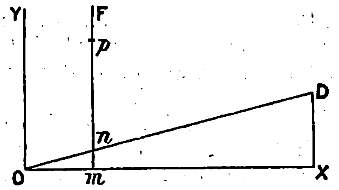

Fig. 15.

representing the current in amperes from one of the observations. Draw mF parallel to O Y, cutting O D in n. From n mark off, along n F, $n p$, the number of divisions representing the terminal E.M.F. in volts for the observation corresponding to the current O m; this will give p as a point on the curve. From the other observations other points can be obtained, and the curve joining all these points is the characteristic curve for that dynamo at the particular speed at which it was run in taking the observations. It is often advisable to make the divisions representing amperes two or three times as large as those representing volts, for by doing this we obtain the curve of a more convenient shape, but it must be remembered that in this case the internal resistance is no longer equal to the natural tangent of the angle representing it as measured, but equals $\frac{DX}{OX}$ where D X equals volt divisions and O X equals ampere divisions.

Thus, supposing the machine had an internal resistance of half an ohm, we mark off on O X, X =, say, 20 amperes, and X D = 10 volts, then join O D.

To use a characteristic curve.

To find what current we shall obtain through a given resistance at a given speed,

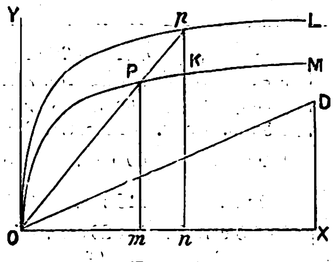

Fig. 16.

Let the speed be that for which the characteristic curve O P K M (Fig. 16) is drawn, and let tan. P O m or $\frac{Pm}{Om}$ represent the total resistance from the point where O P cuts the curve; drop the perpendicular P m, then O m represents the current in amperes gained through the given resistance.

(TO BE CONTINUED.)

A NEW HAND DYNAMO.

Messrs. C. and E. Fein, of Stuttgart, have lately modified their hand dynamo, and rendered it more effective from a double

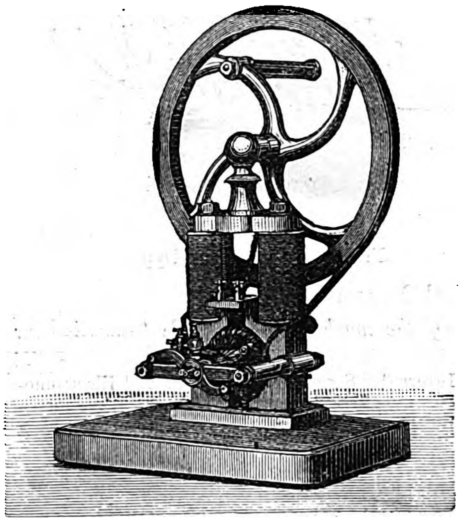

Fig. 1.—Fein's Hand Dynamo.

point of view. In the first place the new machine is cheaper than the older forms made hitherto. Then it is simplified and made less weighty, so as to be easily transported, as well as smaller, features of great importance for small physical laboratories. Figs. 1 and 2 show the machine, made in two forms (with simple and with double transmission). Fig. 1 shows the fly-wheel with crank erected on the top of the machine driving the motive pulley directly by a driving belt; this arrangement is preferable to the use of toothed wheels, as it is almost noiseless. In order to always have the right tension two tension rollers are fitted.

In the other form, Fig. 2 (with double transmission), the fly-wheel is erected on a cast-iron pillar, which has on the top a second axle for pulleys. By this arrangement a greater velocity and thereby a multiplied effect is obtained. The machines are erected on an oaken base which can be fixed upon any table by means of screw-clamps.

The machine is also made without gearing, so that it can be actuated by a prime motor, lathe, or such like.

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Notwithstanding its small proportions, this machine, which only weighs 22 kgr., gives the following results :—

	With simple transmission.		With double transmission.	
	Coarse wire.	Fine wire.	Coarse wire	Fine wire.
Heats to redness a platinum wire ...	400mm. long. 0·5mm. thick.	900mm. lg. 0·1mm. thk	500mm. lg. 0·5mm. thk	1000mm lg. 0·1mm. thk
Melts a steel wire.	200mm. long. 0·5mm. thick.	350mm. lg. 0·2mm. thk	250mm. lg. 0·5mm. thk	580mm. lg. 0·2mm. thk
Decomposes water per minute	120 cm³.	60 cms.	150 cm³	75 cm³.
Deposits copper per minute	230 mg.	115 mg.	280 mg.	170 mg.
Works Swan lamps.	6 of 5 carcels. or 1 of 2·5 carcels.	1 of 20 carc. or 2 of 10 carc.	8 of 5 carc. or 10 of 2·5 car	1 of 20 carc. or 2 of 10 carc.

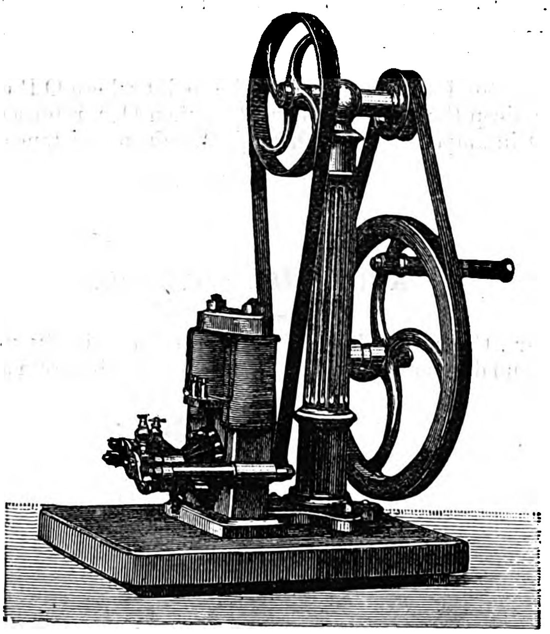

Fig. 2.—Fein's Hand Dynamo.

The Electrical Measurements are :

(*a*) *Of the machine with simple transmission* :—

	Internal resistance.	Strength of the current.	E.M.F. at terminals.	Electromotive force.	External resistance.
Thick wire	0·5 ohm	5 amperes	10 volts	12·5 volts	2 ohms
		8 ,,	8 ,,	12 ,,	1 ,,
		11 ,,	5·5 ,,	11 ,,	0·5 ,,
Fine wire..	12 ohms	1·3 ,,	40 ,,	54·6 ,,	30 ,,
		2 ,,	30 ,,	54 ,,	15 ,,
		3 ,,	15 ,,	51 ,,	5 ,,

(*b*) *Of the machine with double transmission* :—

	Internal resistance.	Strength of the current.	E.M.F. at terminals.	Electromotive force.	External resistance.
Thick wire	05· ohm	7 amperes	14 volts.	17·5 volts	2 ohms
		10 ,,	10 ,,	15 ,,	1 ,,
		13 ,,	6·5 ,,	13 ,,	0·5 ,,
Fine wire	12 ohms	1·6 ,,	50 ,,	71·4 ,,	30 ,,
		2·5 ,,	37 ,,	67·5 ,,	15 ,,
		3·6 ,,	18 ,,	61·2 ,,	5 ,,

These figures show the current of this machine is equal to 20-30 Bunsen cells, 20cm. high, connected in series with a resistance of 0·24 ohm, and an electromotive force of 1·8 volt. Therefore the current is sufficient for all ordinary experiments in a course of lectures on physics that require an electric current. These machines will be found very useful.

CORRESPONDENCE.

THE ELECTRIC LIGHT FOR LIGHTHOUSES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Among the "Notes" of your valuable paper of the 9th August I see a paragraph taken from the *Daily Telegraph*, in reference to the lighthouse experiments at South Foreland. You very wisely point out that it would be rash to draw conclusions from such a paragraph, and give it as a piece of news only. The following facts, therefore, may possibly interest some of your readers :—

Instead of the comparison between the electric light, gas, and oil being unfavourable to the former, the following figures, I have good reason to believe, may, in lack of any better authenticated information, be taken as approximately correct. From a photometric point of view, the electric light, gas, and oil compare together in the proportion of 5, 1, and ·95. From a financial point of view the comparison is as 4, 11, and 1, from which it will be seen that the electric light is far ahead of either gas or oil as regards illumination, while it stands between the two as regards the question of cost. I should add that in calculating the cost the capital outlay has of course been included.—Yours, &c.,

J. F. Albright.

The Edison and Swan Electric Light Company,
London, 14th August, 1884.

IMPROVEMENTS IN ACCUMULATORS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In the last number of *The Electrician* you quote from the *Rêvue Industrielle* that M. Paul Gadot has "made several improvements in the Faure-Sellon-Volckmar accumulators, which have considerably increased their capacity."

Will you allow me to state that the accumulators made by the Storage Company of London two years ago for the purpose of propelling the launch "Electricity" gave a "duty" (if this term is acceptable) of 15 ampere hours per kilogram of lead whilst working at the high rate of 42 amperes discharge through the motor driving the screw. The actual storage capacity of these cells was 13,576 kilogrammetres per kilogram of lead, with a mean E.M.F. of two volts.

M. Paul Gadot's figures are 13 and 9,400 respectively; the improvements, therefore, are not in the direction of large capacity with small weight.

The Electrical Power Storage Company are now constructing cells for motive power purposes, from which I expect to obtain a higher "duty" per kilogram of lead than has ever been attained in any practical application.

I have so frequently referred to the above results, notably before the British Association, the Society of Arts, and the Institution of Naval Architects, that I must apologise for this repetition and trespass upon your valuable space.—Yours, &c.,

A. Reckenzaun.

60, Queen Victoria-street, E.C., August 11, 1884.

CONSOLIDATED TELEPHONE COMPANY'S MEETING.

A CORRECTION.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I observe in your report of the above meeting of my few remarks that I am reported as having used the word "roguery." What I did say was "irregularity." As I disclaim having used the former word, I must ask you to put the matter right in your next issue.—Yours, &c.,

J. H. Buckingham.

35, Wood-street, Cheapside, London, E.C.,
August 13th, 1884.

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ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The accompanying correspondence may, we think, be interesting to your readers.

To avoid possible misconception, it may be better to state, in reference to the last paragraph but one of Mr. Gordon's letter, that this company have not yet concluded finally with the Metropolitan Railway Company, but I hope a contract will be passed shortly.—Yours, &c.,

J. E. PICKERING, Secretary.

The National Company for the Distribution of Electricity by Secondary Generators, 18, Warwick-street, Regent-street, W., Aug. 13, 1884.

(Copy.)

The National Company for the Distribution of Electricity by Secondary Generators (Limited), 18, Warwick-street, Regent-street, London, W.,
Aug. 8, 1884.

To J. E. H. Gordon, Esq., B.A., M.S.T.E., Manager of the Electric Light Department of the Telegraph Construction and Maintenance Company (Limited), 38, Old Broad-street, E.C.

Dear Sir: In your interesting work entitled "A Practical Treatise on Electric Lighting" you are good enough to devote a chapter to our system of electrical distribution by secondary generators.

We are much indebted to you for the very comprehensive manner in which you have treated the question, and we feel sure that you will pardon us for drawing attention to some points which we think you will see upon reflection require further explanation in order to do justice to the subject.

A portion of the remarks we propose to offer are necessitated by circumstances which have arisen since the publication of your book.

On page 185 you say, "The Gaulard-Gibbs apparatus consists essentially of an induction coil, of which the primary coil consists of a long thin wire, and the secondary a short thick one."

This description does not apply to either the form we had in use at the time your book was written, or to the improved form which we now employ. In both forms the same length and cross section of copper are employed for the two conductors, and in the present form these conductors are absolutely identical in all respects, and similarly situated relatively to the iron core. We have adopted this latter design after a long series of experiments.

In effect the apparatus employed on the Metropolitan Railway was composed of columns formed of a cable rolled in two superposed layers of spirals round a cylinder containing iron wires, the cable being formed as follows:—

An insulated copper wire of four millimetres in diameter (No. 8 B.W.G.), through which the primary current passed, was surrounded parallel to its axis by 118 wires (No. 21 B.W.G.) individually insulated, and constituting the induced circuit. Thus the sum of the sections of the secondary circuit was obviously equal to the section of the inductor, and it followed from the central position of the inductor that the mean distance of the two circuits from the central core was the same.

The type of secondary generators now adopted is composed of copper discs of $\frac{1}{2}$mm. in thickness, furnished with earpieces allowing of their being connected so as to form two independent circuits, insulated from one another by means of discs of paraffined cardboard. This apparatus, simple in construction and far less costly than the original model, gives even a higher percentage of effective work, and cannot in any way be said to resemble an ordinary induction coil.

2. On page 187 you say, "In order that the plant which we can now afford may be able to supply the required quantity of electricity, the efficiency of the induction coils must not be less than

$$E_1 = 100 \frac{18000}{14500} = 89\%.$$

I fear that it is not likely that the efficiency will be anything like so high as this."

As a matter of fact, Dr. Hopkinson, after the most careful tests, found the efficiency of our secondary generators to be, singularly enough, precisely what you had considered necessary, viz., 89 per cent., as per his report dated 14th of March last, a copy of which we have the pleasure to hand you herewith.

3. On the same page (187) you make a comparative estimate between the ordinary 100 volt system and a system where the E.M.F. could be increased to 1,000 volts. You admit that the copper in the latter case (our own) would cost £500 only as against £5,000 in the former, but you add £4,000 in the case of employing a current of 1,000 volts for "insulator" as against £2,000 under the 100 volt system. Now, in fact, on the Metropolitan Railway we had a current of nearly 2,000 volts passing over a primary conducting wire 4 mm. in diameter (7·16 B.W.G.) and 15 miles in length; the paraffined tape (used for giving partial insulation to the primary conducting wire) when once saturated by the humidity in the tunnels furnished no insulation whatever, yet the naked primary circuit at the terminals of our secondary generators could be touched without any perceptible derivation.

This installation on the Metropolitan Railway worked without a hitch from dusk till 8 a.m. during five winter months to the entire satisfaction of the company, and we are now treating for the lighting of their entire system from a central station at Neasden over a circuit thirty miles long, the total electrical energy to be distributed being equal to 200 horse-power.

On page 188 you justly remark that, "In very scattered districts (as, for instance, the stations on the Metropolitan Railway, which are now being lighted on this system as an experiment) the proportion of the cost of the copper to that of the cost of the plant in a 100 volt system might be much greater than in the typical one which we have suggested, and in such a case the system might be useful."

We would venture to add that in such a case the cost of copper in a 100 volt system would be absolutely prohibitive, and we take this opportunity of stating, as we mentioned to you recently at a personal interview, that we do not wish to compete where other systems can be employed, but that our special province is to aid all, and commence where previously known systems cease to be operative. In doing so we offer the additional advantage of being able to furnish currents of varying potential, thereby enabling consumers to supply any type of lamp, whether incandescent or arc, as well as motive power. We propose publishing this letter, to which course, as affording us an opportunity of correcting errors, we presume you will have no objection.—We are, sir, your obedient servants,

(Signed) Lucien Gaulard, J. Dixon Gibbs, } per J.D.G.

(Copy.)

Electric Light Department, Telegraph Construction and Maintenance Co. (Limited), E. Greenwich,
Aug. 11, 1884.

The National Company for the Distribution of Electricity.

Dear Sirs: I thank you for your letter of Aug. 8, and am much interested in what you tell me as to the improvements that you have recently made in your generators.

Whenever I commence to prepare a second edition of my book I shall not fail to write to you, and request you to give me full particulars of all improvements that you have made up to that date.

I should, both as a scientific man and as a manufacturer of alternating current machines, be much pleased to see your system successfully tried on a large scale.

I hope that the lighting which you tell me you are about to carry out from Neasden may be complete in time for me to give an account of it in the next edition of my book (the first edition is about half sold).

I shall of course have no objection to your publishing your letter to me and this reply.—I remain, dear sirs, yours faithfully,

(Signed) J. E. H. Gordon.

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THE ELECTRICIAN.

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Cheques and P.O. Orders to be made payable to C. H. W. BIGGS.

Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

With this Number is issued "The Electrician" Supplement No. 5. Subject: The Board of Trade Standard Wire Gauge.

Notes 313
The Elements of Electric Light Engineering. By E. C. Rimington and C. W. J. Crawley. (Continued.) Illustrated 318
A New Hand Dynamo. Illustrated 319
Correspondence .... 320 and 321
Mr. Fawcett and the Telephone Companies 322
Dynamo-Electric Generators. (Continued.) Illustrated ... 323
500-Light 10-inch Dynamo. Illustrated 325
Experiments on Lightning Conductors. Illustrated 326
Electro-Magnetic Ore-Dressing at Oberlahnstein. Illus. ... 326
Thunderstorms 327
The Telephone Companies and the Post Office 328
Legal 330
Companies' Meetings—
Cuba Submarine Telegraph Company 330
The National Telephone Co. 331
The Lancashire and Cheshire Telephonic Exchange 332
Companies' Share List 332

ANSWERS TO CORRESPONDENTS.

ENQUIRER.—*The operation you mention is not usually classed among electrical work, and we imagine the ordinary method of procedure is far cheaper than by electro-deposition.*

P. HOWELLS.—*So far as we know the small dynamos you require are not to be found in the market. Perhaps, however, some reader may be able to help you to find "a dynamo of the smallest possible dimensions that would be of sufficient power for one Swan lamp." The purpose for which the lamp is required renders a battery unsuitable. Do you require a 5, 10, 20, 40, or 100 c.-p. Swan lamp? How do you intend to drive the dynamo if you are successful in obtaining one?*

MR. FAWCETT AND THE TELEPHONE COMPANIES.

The concessions which Mr. Fawcett has offered to the Telephone Companies surprised nobody so much, perhaps, as the companies themselves. Great as is the political power exercised by the telephone interests and by the crotchetmongers who take every opportunity of damaging the State telegraph in the supposed interests of the public, a surrender so instant and so complete was scarcely dreamed of. Mr. Fawcett explicitly exonerates the permanent officials from responsibility for the regulations complained of but now altogether abandoned; he might, we should imagine, exempt them from the responsibility of sweeping those regulations away. To the permanent officials, and to them alone, the decision of the Postmaster-General has probably caused no surprise. Uniformly to yield to noisy clamour is the rule with which they have grown familiar during his administration, and a sacrifice of their own convictions once again at the expense of the Department is rendered easy by the accommodating broad shoulders of its parliamentary chief.

Mr. Fawcett's language partly justifies these observations; but they are based chiefly on our inability to believe that the permanent officers of the Department—men who have large practical experience of the telegraph, of its traffic, its tariff, and its management—could have concurred in framing the recommendations which were announced in the House of Commons last Thursday week. But this is comparatively a small matter. The concessions are made, and will be eagerly accepted. The really important point now is their effect upon the telegraphs belonging to the State, as well as upon private telephone enterprise. The companies have obtained for their property what, in the language of the day, may be called an "unearned increment" of very considerable dimensions; they are now placed on a footing of almost practical equality with the Post Office telegraphs, and all they have got to do to make the balance perfect is to push their advantage on the lines kindly indicated by their official competitor. On the other hand, the Postal Telegraph has now to suffer to the extent of its rivals' newly-acquired gains. But this is by no means all. Mr. Fawcett has made it next to impossible to refuse those further concessions, which will, to all intents and purposes, undo what the law courts, at great cost and labour, secured, namely, the inviolable monopoly which the country had bought and paid for.

This at least is our opinion after considering the situation with as much impartiality as can be given to it. Indeed, it would not otherwise be worth while to criticise the decision were it not for the consequences which are almost certain to follow on it, but which seem to have been entirely overlooked or set aside. The recipients of Mr. Fawcett's bounty were quick to perceive this the moment they recovered from their first astonishment, and forthwith demanded all or nearly all that remained to be given up. The concessions were exceedingly fair, they were even generous—but only "as far as they went;" and *The Times* next day spoke of the "worst evils of official monopoly" being "mitigated" but "not removed," and of Mr. Fawcett's concessions as an instalment of reform which must shortly be followed by measures of a more liberal character. These measures, *The Times* thinks, are to be made practicable by the process familiar to electric lighting companies—the wiping off of capital. With a blank page for its capital account—the purchase money for the telegraphs being struck out—the Post Office could afford to treat the Telephone Companies as if they were "in the position they occupied before the Government laid violent hands on them." So say *The Times* and Dr. Cameron. It happens that it was the companies that laid violent hands on the Government's property; but let that pass. What we have to note is that, much as they have obtained, the companies expect to get more, and we think they will get it.

For example, after virtually cancelling the distinction between telephony and telegraphy, is it possible to retain it in respect to the traffic? We are inclined to agree with Mr. Gray that the restriction forbidding the companies delivering written messages is "unworthy of the right hon. gentleman;" unworthy of anybody who seriously desires, after what has happened, that a distinction so artificial should last. Again, will it be practicable, in view of the 10 per cent. royalty, to permit free competition, much less for the recipient to actively compete on his own account? And while demanding this royalty in all circumstances, how can the Government decline to assist—nay insist—that wayleaves shall be given their clients who have to pay it? Holders of licences will have a stronger case now than ever for demanding protection, and for regarding the Government as a sleeping partner in their business, and as a sharer of its risks so long as a share of its profits is accepted. The royalty we hold to have been a mistake from the very first, and it is now pretty

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plain that this, too, will have to go, when there will be absolutely nothing left to take its place. Its maintenance has made freedom from all restrictions a logical necessity; free competition will similarly relieve the competitors from the burden of the Government tax.

This we think is certain, especially in the face of Mr. Fawcett's astounding confession that he was at first "considerably attracted" by the offer of the companies to guarantee the Government against any loss of local revenue consequent on complete immunity from regulations and royalty. A more impertinent offer was never made to any respectable Government—at all events on this side of the Atlantic; and that an English government official should for a single moment entertain it is a sufficient measure of that official's squeezability, to say nothing of his self respect. We heartily share in the public congratulation that the telephone will now have free play; but what we fear is, that the public will not be so well served under this extreme latitude of freedom as they might have been under a well regulated and united system. In one respect certainly the public must suffer—by the uncontrolled and indiscriminate multiplication of overhead wires, all sort of control over which the postal authority has now completely abdicated. Sixpenny telegrams, too, were almost an accomplished fact, and the public are said to be eagerly demanding this reform. It is obvious that the financial difficulties in its way will be increased by the sacrifices now made to a competing system of telegraphs, the revenue from which will not go into, but rather come out of the postal telegraph purse.

DYNAMO-ELECTRIC GENERATORS.

(CONTINUED FROM PAGE 305.)

*Siemens' Continuous Current.**

This is known, perhaps, more familiarly by the name of its makers, but should be called by the name of the designer of its very ingenious system of winding, Herr Von Hefner Alteneck. It rivals the Gramme for compactness and efficiency, and is a type of many of the best known and most powerful machines. The field-magnets are of the form I have briefly described above as being used in the Maxim machine. They may be either vertical or horizontal, wound with the field coils in series in the circuit, on a shunt, or a combination of the two methods. The armature is cylindrical, the coils being wound in diametrically opposite divisions along the elements of the cylinder and across the ends.

In an earlier form of machine there was no moving mass of iron. The coils were wound on a German silver drum, which rotated outside a fixed iron cylinder carried by a shaft extending through the sleeves of the drum and fixed in position.

A strong magnetic field existing between the poles of the field-magnets and the iron cylinder, the drum, in rotating, caused the coils of wire to cut the lines of force, and thereby developed currents. This has now been superseded by the armature, in which the coils are wound on an iron cylinder direct.

It is curious how many people, and prominent ones, too, have fallen into the mistake which is thus stated in a recent work:—"Actual method of winding up the cylindrical drum armature of a Siemens generator, the method invented by Hefner Alteneck, is an unsymmetrical one . . . . . There are, in fact, a large variety of ways of winding coil upon a longitudinal armature, of which that adopted by Siemens is one, and not the best one."

Herr Frölich, a German engineer, and M. Antoine Breguet both thought they had discovered a new system of winding a drum armature, a more symmetrical one, when trying to describe the Siemens armature. Both of these gentlemen and those who quote them were, I think, wrong, and were led into their mistake by an inspection of the patent drawings of the Siemens machine, or by drawings which were copied from these. . . . . . . Let any one take a single wire, and after reading a description without drawings attached of the Siemens armature, and attempt to wind such an armature, or let such a one attempt to draw a plan of the winding on paper, and he can scarcely avoid making precisely the same thing as is illustrated by Herr Frölich. In other words, he will wind a Siemens armature as it is now and has been wound, but will make a better diagram than that given in the Siemens patent. In short, the last mentioned drawing does not correctly in one sense represent what it is intended to. It is to be remembered that there are the same number of complete coils as there are divisions of the cylinder; that two coils shift polarity at the same instant, and that consequently there must be in each pair of sections two independent coils occupying the same radial position.

In fact, where there are two poles of wide extension, and coils are wound in such a manner as to occupy symmetrical positions with regard to the neutral line of the field, there is but one real way of winding double coils in diametrically opposite divisions, and when properly connected they must be joined in one way only—there is no other. The methods proposed by M. Breguet are, electrically considered, unsymmetrical, because the two active parts of a coil are at times on the same side of the commutator line—that is, in the same field, and hence antagonistic. Reference to Fig. 15, and also to the development, will explain the method of winding with a single wire. I will take Fig. 15, speaking as "down" the plane of the paper when winding along an element of the cylinder away from the spectator, and calling the ends face and back.

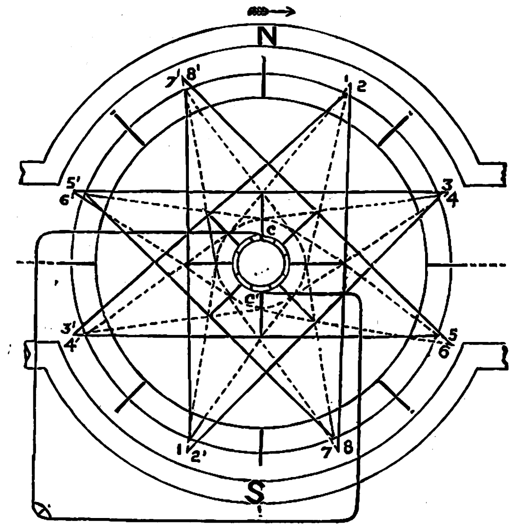

Fig. 15.—Winding of Siemens' Armature.

Starting with 4, wind down 4, across back, up 4′, across front to 2; down 2, across back, up 2′, across face to 8′; down 8′, across back, up 8, across front to 6′; down 6′, across back, up 6, and across front to 3′. Four coils have now been wound, and the eight divisions are all occupied. We now continue in regular sequence, but since we have gone half way round, and all divisions are occupied, we must put the remaining coils on top of the first, and we really wind in the reverse order, because starting on opposite elements of the cylinder. Hence we wind down 3′, across back, up 3, and across front to 1′; down 1′, across back, up 1, and across face to 7; down 7, across back, up 7′, and across face to 5; down 5, across back, up 5′, and across face to join 4, the first coil end, to which it is joined. There is now a double set of coils wound with geometrical and electrical symmetry, and forming a closed circuit. Now join the lights in seriatim to the strips of the commutator. If the circuit which is now established be followed, it will be seen that entering, say, at C, the current splits, passes over two equal paths, and that it leaves at C′, after having traversed every element. It would further

* Vide *Electrician*, Vol. X., p. 256

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be seen that the currents in all the elements on one side are in one direction, and on the opposite side of the cylinder they pass in the reverse direction. In practice a single wire is not used, but enough to wind the proper amount in each coil, the ends being thus connected in a proper manner. The coils may be wound either singly or two at a time, the whole or only half of the winding being completed at once. This last will give a range of coils of practically the same resistance. When wound as described with a single wire the banking up of the wire on the ends of the cylinder produces an irregularity of resistance and length of coils, provided the same number of turns are laid on. The banking up of the wire on the ends is not avoidable, and causes some heating of necessity. The cylinder may be solid, or built up of rings or discs. There is a distortion of the lines of force and formation of transversal poles in this machine, as in the Gramme, and the brushes must therefore be given a lead. I believe the brushes are set at a given lead, but I think movable arms better. The machine is very compact, well made, very efficient, and powerful. It converts about 90 per cent. of the absorbed mechanical power into electrical energy.

*Weston.**

This machine has an armature wound on the Hefner-Alteneck plan, although its invention, considerably later, may have been perfectly novel with its maker. The cylinder is built up of a large number of the rings cut from soft iron, and having a range of widely spaced projections on the outer periphery. These rings are built up to form the main part of the armature coil, spaces being left between for ventilation. The ends are formed of iron heads with projecting pieces in wake, or in extension of the ribs which are formed by the ring projection. Several slight modifications have at times been made in the method of laying on the turns of wire, the coils being wound singly, in twos, and also side by side in the same divisions of the surface, but the connections are always those of the Hefner-Alteneck system. The connections to the commutator plates are by wires passing through a hollow shaft, this arrangement being made necessary by having the commutator outside the bearing. The commutator strips are cut obliquely, so that the line of contact, which is parallel to the axis of the spindle, touches upon two of these strips at once, insuring continuous contact and very slight sparking. The brushes are curved, so as to give end contact only, and are built up of ten or twelve thin strips, each cut into three tongues. This gives elasticity and pliability. They are mounted on a swinging frame to allow of change of position. Compound field-magnets are used, but each is made not of two large coils, but of six smaller ones, three on a side, and enclosing three circular legs, which are detachable. The part which embraces the armature is grooved or cut into tongues, and the edge of these form an elliptical outline. This form is adopted because it is claimed that the induction at different parts of the cylinder is not the same, but extends from the centre outwards.

The breaking up of the surface affords more room for ventilation, and cuts off the Foucault current set up by the reaction of the armature on the field. These machines are finely designed, run very quietly and smoothly, and are of high efficiency, probably second to none of their class. The mechanical work is of high character.

Edison.†

Of this make there are two distinct classes, one the central station dynamos, and the other embracing those designed for isolated systems. The Edison machines were designed to form part of a distinct and complete system of lighting, and, as such, they possess some peculiar features not noticed in other machines. Since heavy currents are necessary for supplying incandescent lamps in parallel circuit, and a fixed difference of potentials must be maintained at the terminals, armatures of very low resistance were adopted, and the field-magnets, which were of an unusual mass of iron, excited by a shunt current passing over a over a path of high resistance. In the smaller machines the field-magnets are wound with a large number of turns of wire, with an aggregate resistance of about 40 ohms. This, with a terminal potential of 110 volts, would give a current in the field of 2¾ amperes, and require but two-fifths of a horse-power of electrical energy. These magnets stand on a zinc plate, which is bolted to a cast-iron bed-plate, with grooves in the lower side to take slide-bars.

Wire Armature.

The armature is built up of a large number of exceedingly thin discs of soft iron, separated by tissue paper, and strung upon a wooden core. They are firmly bound together by tie-bolts, and outside of the cylinder so formed are wound the coils. Of these there are a large number; they are wound on a modified Hefner-Alteneck system, and firmly bound in place by wire bands to prevent the strands from flying out. The ends are covered with a wrapping of cloth, and the field-magnets are similarly protected. The commutator is very wide and thick, and hence is adapted for long runs. The brushes are formed of alternating layers of wire and thin strips of copper, are a third of an inch thick, and are the best I have seen for heavy currents. They are mounted in a swinging frame to allow of proper adjustment, and this is so well effected that the sparking is remarkably slight. The armature is mounted with outside bearings, and all end-strain thus avoided, although making it a little inconvenient for the belting. The circuit is closed by a switch. This machine, the Z, is designed for 60 to 65 lamps, the resistance of the armature is 20 ohms when warm, and the consequent loss is about one-half a horse-power. The machine runs quietly, steadily, and is highly efficient.

The use of such large masses of iron in the Edison machine was at one time looked upon as ridiculous, but, as pointed out also by Marcel Deprez, this is conducive to economy and efficiency. The reason is easily explained, and it is because a much more powerful field can be obtained where large masses of iron are used than where small ones are, because the saturation point is not so easily reached.

Other sizes of these machines are made for 150 and 250-light, and these are in general appearance like a combination of two and three of the Z machines—that is, there are two and three sets of field-magnets of precisely similar construction, ranged side by side, and with larger armatures of similar build. The field-magnets are coupled in parallel circuits, two legs in series.

Bar Armature—Central Station.

Another armature has been used with the Z, which is called the bar armature. The body of the cylinder is the same, but instead of using wire thick rods of copper are laid on, and the requisite connection made across the ends by copper discs; that is a coil is formed of two bars and two copper discs. This is a highly economical armature, and the resistance is very low. This form has been abandoned for the smaller machines, but is used for the central station dynamos. These are intended at the present economy to supply 1,000 to 1,200 lights of full power, 16 candles.

These armatures are very heavy, weighing four or five tons, and the bars, of which there are from 90 to 100, of large cross sections. The resistance is consequently very low, being, when cold, less than ·004 of an ohm. The connections are plated with gold to prevent oxidisation. The field-magnets are horizontal, have twelve legs (eight at the top and four at the bottom), and the pole-pieces are very heavy. The armature is driven direct from a high-speed engine, with coupling between. The speed is about 350 revolutions for the single dynamo. It is proposed to drive two armatures with a single engine of 400 horse-power, and at a somewhat lower speed. These machines can be coupled in parallel circuit, but in the case of the double armature the two will be connected in series, and the sets in multiple arc for a proposed new system of distribution. The very heavy currents taken off by sets of ten thick brushes, and the commutator blocks are removable.

(TO BE CONTINUED.)

* Vide *Electrician*, Vol. XI., p. 545. † *Ibid*, Vol. VIII., pp. 28 and 202.

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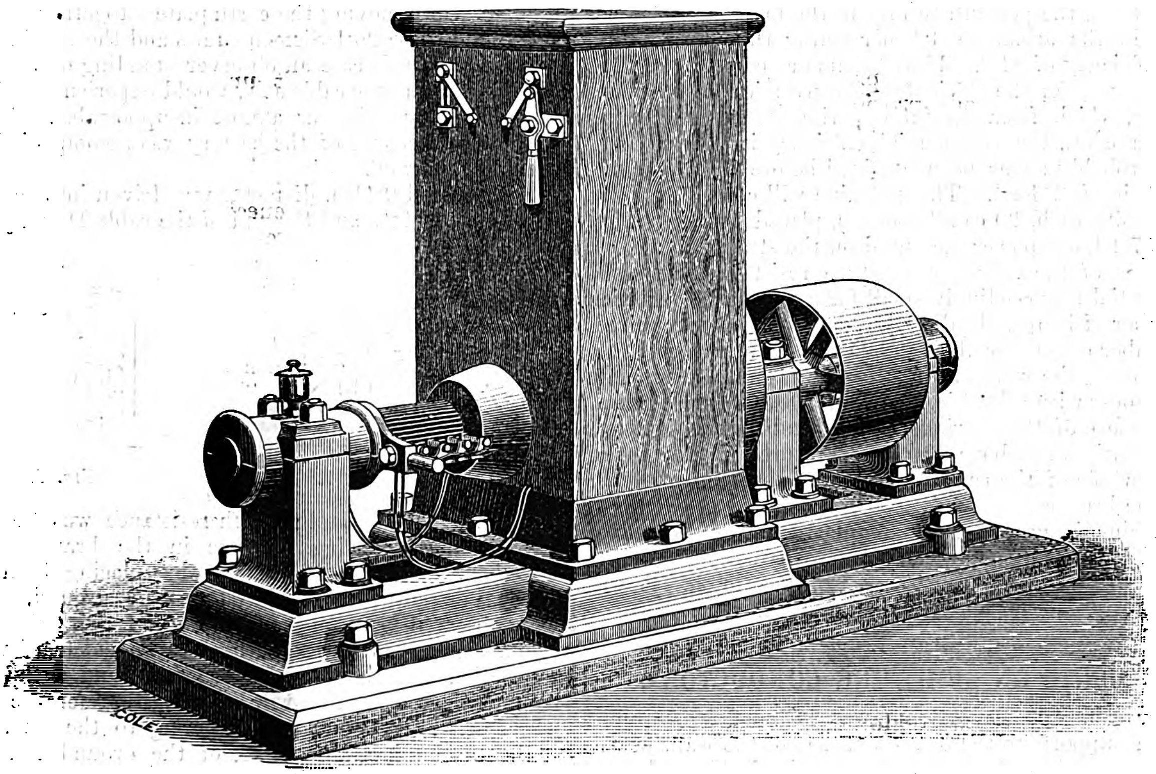
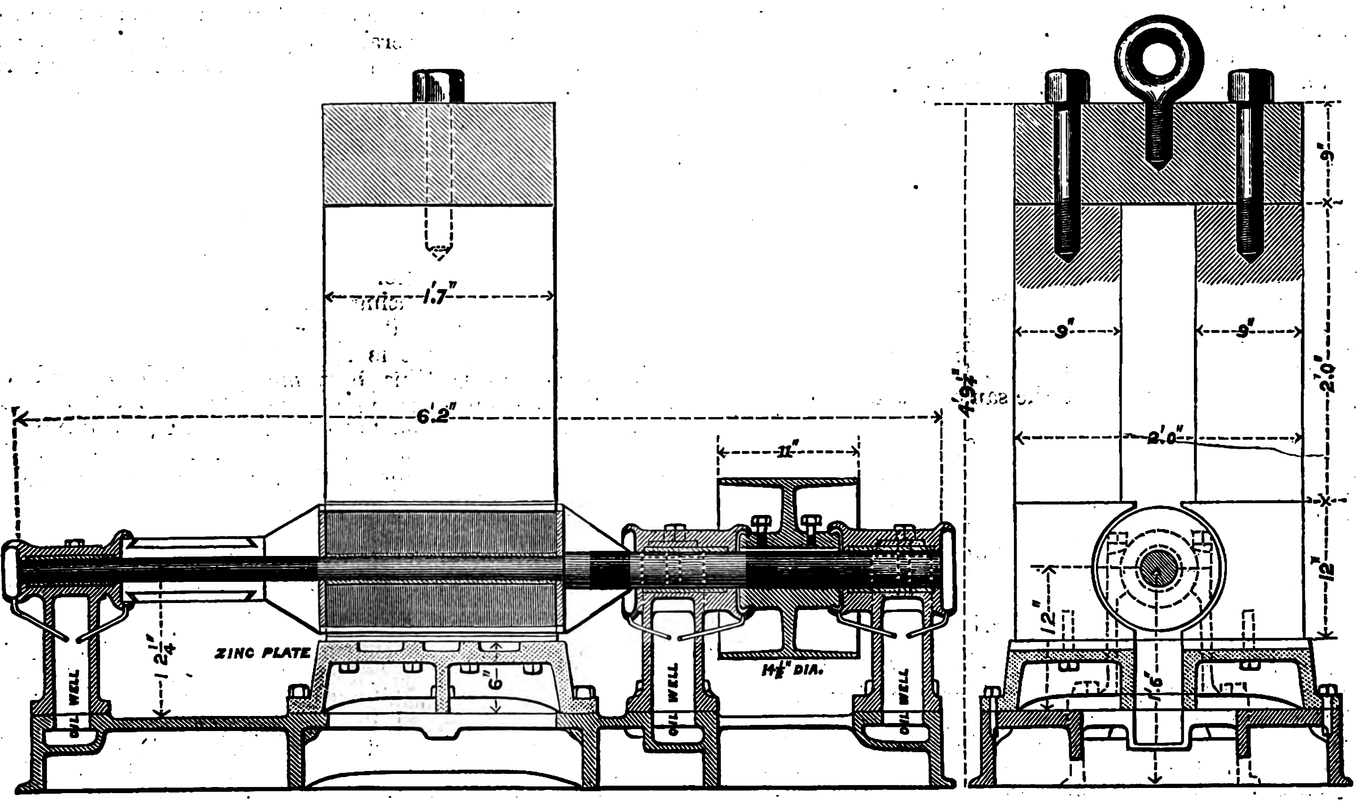
500 LIGHT 10-INCH DYNAMO.

This machine is the first that has been constructed on the Edison-Hopkinson plan to carry 500 Edison A lamps, and possesses several points of interest. The general dimensions strong current of air is automatically drawn between the armature and the fields of the magnets by the rotation of the armature. For the sake of protection, and to add to the external



500 Light Edison-Hopkinson Dynamo.



LONGITUDINAL SECTION TRANSVERSE SECTION

500 Light Edison-Hopkinson Dynamo.

of the dynamo are the same as those of the 250 light, namely, slow speed machines. The driving pulley is provided with an outside bearing, and the length of the bearings increased. A appearance of the machine, the pole pieces of the magnets and the yoke are cased with polished wood. The upper casing is convenient for fixing the switch and magnet connections. For

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110 volts and 350 amperes in the external circuit the dynamo runs at 820 revolutions per minute.

The resistance of the armature is 0·0108 ohm, and of the magnets 16·4 ohms. Hence, when working with its full load, there is a loss of only 737 watts in the magnet coils, and 1,374 watts in the armature, while 38,510 are available outside the machine. Thus, the percentage loss in the magnets is 1·8 per cent., and in the armature 3·4 per cent,; this gives a total electrical efficiency of 94·8. If we assume as correct Mr. F. S. Sprague's figures for the efficiency of conversion of machines of this type, which from careful experiments he deduced as also 94·8 per cent., the commercial efficiency is 90 per cent., which has probably never been attained before in a machine working at its full load. The machine will carry 640 Swan lamps (55 volts each, 20 candle-power), placed two in series, absorbing 57·4 horse-power measured on the strap.

On account of the very low armature resistance, the variation of potential is exceedingly small for a very large variation in the number of lamps. If absolute compensation is required, a small number of series coils is sufficient for the purpose.

Before leaving the works the machine was run continuously for twelve hours with a load in excess of 500 Edison A lamps. The temperature of the bearings at the end of the run was only 12° centigrade above the temperature of the room. During the whole of the run there was no sparking whatever visible at the brushes.

The machine is now working regularly, driven by one of Mather and Platt's engines, with its full load of lamps, at the mills of Messrs. Wright, Turner, and Co., Pendleton. It was made by Messrs. Mather and Platt, of Salford.

EXPERIMENTS ON LIGHTNING CONDUCTORS.*

A copper cable, 65 yards long, was fastened by 13 uninsulated iron supports to the outside of one of the walls of the Polytechnic School in Dresden. One end of this cable was carried into a well 16 yards from the building, and containing water to a depth of 6 yards, and could there be joined on to earth plates of various dimensions. By means of a connection leading from the cable into the laboratory strong discharges from a battery of 74 Leyden jars could be sent into the cable,

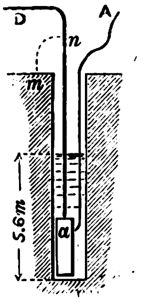

FIG. 1.

the spark being transmitted between two metallic balls kept at a constant distance. The arrangement will be understood by reference to Figs. 1 and 2, the first showing the well with cable D and earth plate *a*, the second the battery B, cable D and electrodes X. The outer coatings of the jars were in metallic connection with the water-mains W by a very stout copper wire, and might therefore be taken to be always at the potential of the earth. A branch circuit, A Z w_1, joining the earth plate with one of the branch pipes connected with the water-mains, and having at Z two smaller metallic balls, served to illustrate by the spark passing between them the principle of lateral discharges from a lightning conductor. Every time a disruptive discharge took place between the balls X in the primary circuit another discharge occurred between the balls Z in the secondary circuit, and this took place notwithstanding that the earth plate, which measured 13ft. by 1ft. 7in., was entirely submerged in the water of the well.

For the purposes of comparison the sparking distance at X was kept constantly at 0·4in., that at Z was varied to get its maximum for each arrangement. With an earth plate of the size mentioned above the earth resistance between *a* and W was found to be 2·3 Siemens units, and the maximum sparking distance at Z 0·021in. With an earth plate half as long the resistance was 3·0 Siemens units, and the sparking distance 0·027in. On removing the earth plate altogether the resistance was found to be 26·1 Siemens units and the sparking distance 0·128in. In this case an observer standing on the ground at *m*, and touching the cable at *u*, would experience a shock which the author describes as almost insupportable. At the same time each discharge of the battery was accompanied by a loud report in the well.

An iron rod 0·41in. diameter was driven into moist ground to a depth of 6ft., and the end of the cable D was joined to it

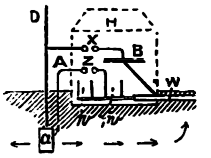

FIG. 2.

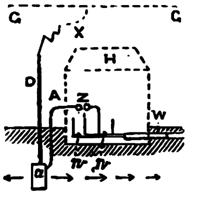

FIG. 3.

(Fig. 4). In this case the earth resistance was 30 S.U., and the maximum sparking distance in the branch circuit was 0·138in. Shocks could be felt by placing both hands at unequal distances from the rod on the ground, and sparks were observed between the electrodes of two wires, *b* and *c*. The analogy between the author's arrangement of a battery in connection with the lightning conductor and a thunder cloud hanging over a building will be seen by reference to Fig. 3, where G G is the cloud corresponding to the internal coating of the Leyden jars, the surface of the ground containing the water-mains corresponding to the outer coating, and X the stroke of lightning corresponding to the spark from the battery. The lateral or secondary discharge through Z must therefore be expected to take place in all cases where large metallic masses connected to earth come near to the lightning rod

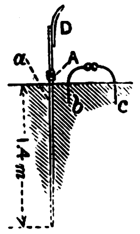

FIG. 4

without being in actual metallic connection with it; and the author considers it a most important condition for the safety of a building that all metal about the building should be in the best possible metallic connection with the system of lightning conductors. The town mains for gas and water should also be included in this connection.

* From a paper by Professor Dr. Toepler, published in the *Elektrotechnische Zeitschrift*, June, 1884.

ELECTRO-MAGNETIC ORE-DRESSING AT OBERLAHNSTEIN, GERMANY.

A few years since the announcement was made through the technical press that a system of electro-magnetic ore-dressing had been tried in Germany. The plant, which has now been at work for three years at the Friedrichssegen mine, near Oberlahnstein, has been recently described in greater detail by Herr Otto Heberle, at a meeting of the Verein Deutscher Ingenieure. The Friedrichssegen mine produces ore containing a good deal of iron ore and zinc-blende, which are difficult to separate, because their density is nearly the same. Two classes of ore are mined, cobbing ore, from which some pure saleable ore is separated by hand-sorting and smalls. That part of the cobbing ore that is rejected in sorting goes to the electro-magnetic separators, while the smalls are dressed in the usual manner. Middlings, containing blende and iron ore, are

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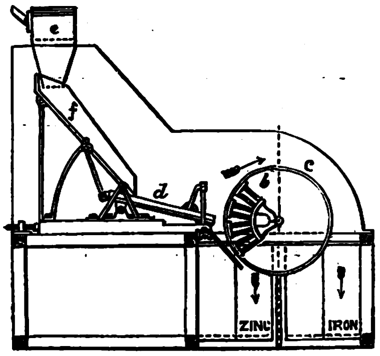
obtained also in this dressing, and they too go to the electro-magnetic plant. The material for that process obtained by sorting ranges in size from 40 to 120 millimetres, while the ore from the ordinary dressing plant is 6-millimetre stuff. It is worked by first roasting, separating by means of the electro-magnets, and then jigging.

The object of the roasting is to prepare the material for the subsequent process by converting the iron into magnetic oxide. The picked lump ore is roasted in a shaft-kiln, with coke-dust as fuel. The consumption of fuel is slight on account of the sulphur in the blende, not being greater than 110 pounds to 8 tons of ore, which are daily put through one furnace. The furnace requires the labour of two men. The roasted ore goes to a rock-breaker and to a pair of rolls below it, which reduce the rock to 5-millimetre grain, and deliver it to an elevator that takes it to the electro-magnets.

The fine middlings obtained in the wet dressing are worked in one reverberatory furnace with a hearth 12 feet wide and 38 feet long, provided at each side with a fire-place, 5 working doors, and a discharge opening, and in one small reverberatory, the hearth of which is 6 feet wide and 22 feet long, and which is provided with one fireplace, two working doors, and a discharge opening. Roasting takes an hour and a half. These two furnaces have a capacity of from 18 to 20 tons in twenty-four hours; but of course the cost of fuel and labour is much greater, being fully three times as large as that of roasting the lump in kilns. After being roasted, the ore is spread out on a cooling-floor, is then passed over screens to get out sintered lumps, and is then delivered by a bucket elevator to the hopper into which the crushed and calcined lump ore goes. In this hopper, the ores are put through a screen with 4-millimetre mesh, the fines falling through chutes to the magnetic separators, while the coarse is crushed by a small set of rolls.



The dressing is done by 16 electro-magnetic apparatus arranged in sets of four in pairs above one another. The upper pair receives the ore from the chutes, and partially separates the blende from the iron. The products obtained are worked over once more in the lower apparatus. They are, 1st, a mixture of blende and quartz; 2nd, iron ore; 3rd, blende middlings; and 4th, iron ore middlings. The middlings are treated over again. As there is a good deal of dust in working, all the apparatus are connected with an exhaust-fan. The apparatus, which is shown in the accompanying diagram, is constructed as follows:—The electro-magnets are attached to a solid stationary shaft. In front of the brass cylinder *c*, which revolves around the magnets, is a shaking-table *d* and a distributor *f*. The ore drops from the chutes and through the funnel *e* upon the distributor and the shaking-table, which delivers it on to the brass cylinder *c*. As soon as the ore reaches the vicinity of the cylinder, the particles of magnetic oxide are retained, while the blende drops by. By the rotation of the cylinder in the direction indicated by the arrow, the particles of iron finally escape beyond the action of the electro-magnets and fall off at the other side of the cylinder. By adjusting the distance of the shaking-table from the cylinder, different sizes of ore may be treated. The electric current is generated by dynamos, one machine that requires a motive power of one horse-power being sufficient to supply four separators. With two sets of four apparatus of the plant now at the Friedrichssegen mine, 24 metric tons of ore, running from 12 to 15 per cent. of zinc, and from 20 to 22 per cent. of iron, can be treated for each set in twelve hours, yielding a product of 7 tons of blende and 18 tons of iron ore. The former contains about 33 per cent. of zinc, and the latter from 36 to 38 per cent. of iron and 10 per cent. of manganese. The iron ore is sold as such. The zinc ore is worked further by screening to obtain 1, 2, and 3-millimetre sizes and jigging. The object is to get rid of the gangue in the product, and to obtain the lead in it. In this manner, the percentage of zinc in the ore is carried up to 38 per cent., while the lead ore carries about 65 per cent. of lead and 0·004 per cent. of silver. The fine dust is washed in buddles, yielding lead beadings carrying 55 per cent. of lead, and zinc beadings containing 32 per cent.—*Engineering and Mining Journal.*

THUNDERSTORMS.

Once again within the past three or four weeks the intense heat we have been experiencing has terminated in a series of violent thunderstorms, which have been more than usually destructive to life and property. To detail every instance of buildings or animals struck by lightning would, judging from the pile of clippings from the provincial and daily press now lying before us, fill several pages of *The Electrician*, and serve no good purpose. We therefore propose to pick out only a few instances of destruction of property or life where the details have been recorded more fully than usual. Surely the Meteorological Office might institute inquiries into the surroundings of the spots on which Lord Lauderdale, the painter at Ripley, and the labourer at Ormesby met their deaths. Could they not obtain the evidence given at the inquests, and supplement it by examination of the locality where the lightning stroke occurred? We should have thought so. The details collected with considerable pains from various papers, which are given below, are interesting as news, but are almost valueless for scientific purposes.

The first series of storms broke over the British islands on Saturday last. In the Rossendale Valley, between Haslingden and Accrington Moors, in Lancashire, the storm was marked by a very heavy fall of hail, the stones being of unusual size, variously stated as from one to three inches long. That they must have been unusually large, and have fallen with considerable force is proved by the immense destruction of windows and greenhouse glass which is recorded. On the same day at Darwen a man named William Marsden was killed, and another man named Richard Farnworth injured by lightning whilst playing football. A stoker named Carrington, employed at Messrs. Craik's Collieries, near Barnsley, was struck by lightning whilst in the firehole, and seriously hurt. At the Chapeltown Railway Station, according to the *Sheffield Independent*, a ball of fire dropped in the midst of the passengers, but without doing them any injury. The wires in the signal box were, however, destroyed. The following details of lightning strokes and their results are from the same paper:—"In Barnsley the lightning struck a house in Somerset-street, occupied by Mr. Darham. Passing down the chimney it filled the house with soot, set fire to a cloak which was on a sewing machine, and spoilt a dress. It was observed to pass through a house on the opposite side of the street occupied by Mrs. Rowse, and burst with a loud report in a back garden. At the same time it struck another house in the same street, occupied by Mr. Hayes. The house was filled with soot. Mrs Hayes was hurled violently to the floor, but was not seriously injured. During the storm a house at Handsworth, occupied by Richard Foster was struck by lightning, the electric fluid coming down the chimney, displacing some of the brickwork and breaking the pictures hanging upon the walls in the room, passed through the wall into the adjoining cottage, occupied by Miss Swann, and disappeared again through the ceiling, doing considerable damage to the plaster, &c. In Foster's house were several children. One of these was cut severely upon the face, and a second was burnt upon the body, and the third was also injured in a similar manner. Foster's wife was in the house at the time. At Clowne the electric fluid struck the chimney of the house occupied by Mr. Thomas Fenton Salvin and family near the Cross. The fluid displaced the masonry work of the chimney, and passed down into the kitchen, causing the utmost alarm, and filling the room with sulphur, soot, smoke, and dust. A gun, which previously hung over the fireplace, was dislodged and hurled across the house, and was found doubled up under the wringing machine, and the large beam supporting the upper chamber was splintered by the electric fluid passing along it into an adjoining washhouse. At Glossop the lightning struck the chimney of the house of Charles Shepley in Surrey-street, where it displaced a number of bricks, and after travelling part of the way down the chimney burst a hole through the brickwork and entered the front room, where it swept the carpets off the floor, and threw them all in a heap. The fluid seemed to have swept round the room, and then found its way out of the window, which was open. The railway station buildings at Worksop were struck by lightning. Fortunately very little damage was done, but as the platform was thronged with people some fright was occasioned among those present. The fluid struck at the east end, and appeared to follow some of the iron rods which form the support of the roof, running along one for some yards, and then exploding with a sharp smack quite distinct from the peal of thunder which followed."

Another paper states that a ball of fire was seen to descend at Stratford-on-Avon, close to Shakspeare's birthplace in Henley-street, but did no damage. The *Newcastle Daily Chronicle* says:—"At Low Staples, the

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farm of Mr. Wm. White, the chimney of the back kitchen was struck by the fire and knocked to pieces. The electric fluid seems to have divided at the chimney, and to have struck both the interior and the outside of the building. Several articles were damaged; for example, a strong stone whetstone, lying on a shelf in the back kitchen, was split into two portions, one of which was left on the shelf and the other hurled to the floor, and a gun, in cover, had the cover singed and the muzzle rather doubled in. Mr. White himself was standing at the stable door, and was lifted off his feet by the electricity. He experienced a painful sensation, as if his legs were being torn off above the knees, and still feels a peculiar numbness and stiffness about his leg joints. His eldest daughter also seems to have been somewhat affected by it, as she felt pain and stiffness about her ankles. The Dalton Fell, a rough pasture, covered with whins, &c., was set on fire by the lightning."—The *Yorkshire Post* says:—"An inquest was held—before Mr. Bladon, deputy-coroner—on Monday afternoon, at Haxey, near Gainsborough, on the body of Mrs. Louisa Major, the wife of a postman, who was killed on Saturday by lightning in her own house. During the height of a terrific storm the attention of the next door neighbour was attracted by smoke proceeding from deceased's house. On entering they found her dead, and the woodwork of a sewing machine on fire together with other things. The wall was hot and blackened and the room full of soot. A child nineteen months old sitting on the floor was uninjured, although covered with soot. Dr. Eminson said the electric fluid had been attracted by the sewing machine, and the jury returned a verdict to this effect."

M. G. F. Roumieu, coroner for West Surrey, communicates the following to *The Times*:—"I held an inquest recently at Ripley, near Woking, on the body of George Henry Mitchell, a painter, who was killed on Saturday last by being struck by lightning. From the evidence it appeared that deceased, who lived at Battersea, had been employed at Ripley Court, and, having finished his work, was proceeding to Weybridge Station, with the intention of returning home; on his way the thunderstorm came on which appears to have done so much damage in other parts of the country. He was seen by a boy to take shelter under a large tree which stands in a meadow by itself. Almost immediately after the deceased got under the tree a vivid flash of lightning was seen, and deceased was observed to be lying on the ground. A man at once went to the spot and found him lying on his face quite dead. The doctor who examined deceased said his face was perfectly black, all the hair on his face and head singed, and the tympanum of his left ear ruptured. Deceased had on a leather belt with an ordinary metal buckle; the clothes around and under it were burnt and the flesh charred; his felt hat was very much broken in on one side, and his boots, which were nearly new, presented a very extraordinary appearance, the laces were completely charred and broken up almost like tinder; on the inside of each boot, just at the instep, was a rent in the leather large enough to push an egg through, by the exit of the electric fluid into the earth. The tree under which deceased was standing had been struck by lightning a few years ago and very much damaged as it was on this occasion. I know of several instances where trees have been struck by lightning more than once. Can there be any particular attraction for lightning in these various spots?" All the above accidents occurred during the storms of Saturday.

The parish church of Glaurinnes, Banffshire, was struck by lightning on Monday afternoon. The belfry was completely consumed and great part of the roof burned before the flames could be checked, while the bell fell down the shaft, and much damage was done to the interior of the church.

On Tuesday last a fresh series of storms broke over the country, again doing an immense amount of damage. At North Ormesby, near Middlesborough, a very similar accident occurred to that reported in our issue o the 2nd instant as having happened at Nottingham, when a milkman was struck dead in the streets. In this case, however, it was a woman who was struck whilst selling milk, and the report merely says that she was rendered insensible. A man engaged at Old Ormesby in sprinkling lime in a field was, however, struck dead.

The lightning entered a house in the village of Whitlets, in Ayrshire, Scotland, smashed the grate in one of the rooms, passed into the kitchen, and broke a large piece out of the hearthstone. A woman sitting by the hearthstone was uninjured. At Glasgow a flash was observed to strike the steeple of St. Mark's Free Church, cutting away a part of the ornamental stonework and shattering the slates, three large holes being made in the roof. At the same place three men, while erecting a stack, were struck by lightning in Swanston-street, and rendered insensible. One named William Herbert, sixty-three, was so seriously injured that he had to be conveyed home; but the other two shortly afterwards recovered. The roof of the Naval School on the south bank of the Clyde was stripped completely off by lightning. The roof of the Bonnington Sugar Refinery was struck by the lightning, which also entered the police station at Newhaven, near Edinburgh, and ignited the gas, and destroyed the wire communication with the head office. In the Lauder district the Earl of Lauderdale was struck by lightning while on the moors. He was mounted on a pony, which was killed under him, and was proceeding across the Braidshaw Rigg, on the Lauderdale estate, when the storm was at its height. He was struck on the forehead by the lightning, which made a deep wound on his forehead and breast. The fluid melted his watch and chain, and also part of the case, but did not stop the watch, and then, being diverted into two currents, ran down each side of his left leg, the course being plainly traced by the scorched mark which was made. His clothes were also burnt. The deer-stalking hat which the earl was wearing at the time was torn to shreds, and was thrown by the shock in one direction, while the pony and its rider fell in another. The earl was taken to the nearest farmhouse, where he regained consciousness after a time. During the afternoon he continued in a very dangerous condition. He became comatose about eleven o'clock at night, and died in less than an hour afterwards. A man named Taylor was killed by lightning at Little Langton, near Northallerton, a child in his arms escaping uninjured. At Levisham, near Whitby, hailstones fell fully 1½in. in circumference.

Continuing our account of Tuesday's storm, the lightning struck the telegraph wires which cross the Mile End-road, East London, one of the wires being severed and falling across the carriage way. One paper says:—"A terrible thunderstorm prevailed on Upper Deeside. Huge balls of fire were seen rolling down the slopes of Lochnagar, and the buildings at several farms were struck by lightning." Another paper describing the storm at Dundee says:—"The effect of the lightning play was brilliant in the extreme. The lightning sometimes darting in brilliant fire balls, which seemed to burst just over the earth." At Leith a four-storied house in Mitchell-street was struck by lightning, which forced out the firegrates in the rooms on the second and third floors, severed the gaspipes and ignited the gas on the top floor, passed through the ceiling, and stopped a clock. At Bacton, near Norwich, a house belonging to Mr. G. Smith was struck by the electric fluid, which passed through the roof and on to the staircase, where the wife of Mr. G. Little was passing. The woman was killed instantaneously. Her infant, about twelve months old, which was in her arms at the time, escaped, although the hair on one side of his head was burnt off. At Canterbury the lightning seems to have passed through one window of the military washhouse, where a number of women were at work, and passed out of the door, fortunately causing no injury. A chimney stack in the married quarters was also struck. The electric fluid passed down two of the flues, dislodging large quantities of soot and bricks into rooms occupied by Private Barnett, 8th Hussars (up stairs), and Private Mallen, 12th Lancers (ground floor). Fortunately, no one was in the apartments of the former, but a great deal of damage was done, and the place set on fire. Corp Levison, 13th Hussars, was struck and knocked down, while Regimental Serg.-Major Martin received a shock.

On Wednesday morning early, while a terrific thunderstorm was passing over Fylingdales, near Whitby, Yorks., the lightning descended the chimney of a farmhouse at Stoup Brow, near Robin Hood's Bay. The house is occupied by Mr. Robert Stainthorpe, who, with his wife and child, were in bed at the time. The electric fluid entered the room where they were in bed, set fire to the bedclothes, and did other damage. Mrs. Stainthorpe was struck by the lightning and remained insensible for two or three hours, but she afterwards fully recovered and is not seriously hurt. The child also escaped uninjured. Mr. Stainthorpe was not quite so fortunate, as he was struck by the lightning and badly burnt on one of his legs. He is now doing well under medical treatment. It is a remarkable fact that Mr. Stainthorpe's silver watch and chain, which were hung up against the ceiling near the bedside, were destroyed by the lightning, the silver being melted.

THE TELEPHONE COMPANIES AND THE POST OFFICE.

The following is the report of the discussion on the policy of the Post Office with regard to the telephone companies, which took place in the House of Commons on Thursday, the 7th inst. Our report is from *The Times*:—

On the vote to complete £1,734,589 for the Post Office Telegraphs,

Mr. Fawcett said—Knowing the great interest that is taken in the question of telephonic communication by many hon. members on both sides of the House, I think it will be convenient to the Committee, and will save time if I at once explain the decision which has been arrived at by the Government on this subject [hear, hear]. On many occasions I have stated that we have been most anxious to afford every facility for telephonic communication which is compatible with due regard to the interests of the revenue. I am free to confess that during my short official experience no question that I have had to deal with has presented so many difficulties, and I trust the Committee will accept the assurance that, in attempting its solution, I have been actuated by no other motive than a desire to do what I believe would most conduce to the advantage of the public [hear, hear]. I feel that no good would result from occupying the time of the Committee by going over bygone controversies, and therefore I will at once state that, after taking into consideration all existing circumstances, I have come to the conclusion that, in order that the public may enjoy the facilities with regard to telephonic communication which, in my opinion, they may fairly claim, it is desirable to give greater freedom to private enterprise by relaxing some of the conditions contained in the licences which have been granted to private telephone companies [hear, hear]. This being so, we have to consider what are the conditions on which telephonic communication should be supplied by private enterprise in order to secure, as I have already stated, on the one hand such facilities as the public have a right to demand, and on the other due protection for the Revenue. With the view of obtaining all the assistance I could in determining this question, I, some weeks since, asked the telephone companies to furnish me with a statement of their views upon the subject. The United Telephone Company and its affiliated companies shortly afterwards, in response to this request, submitted three distinct proposals, which I will proceed briefly to describe. Before doing so, I may remark that from four telephone companies not affiliated with the United Telephone Company I have also received statements of their views which, except in one particular, do not vary in any important respect from those of the United Telephone Company. The point on which they specially insist is protection from competition within towns in which they carry on telephone exchange business. This is a suggestion which I think ought not for a moment to be entertained [hear, hear]. Reverting to the three proposals received from the United Telephone Com-

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pany and its affiliated companies, the first is that each company should be allowed to carry on business within the district for which they may hold a licence in any way they may think fit, and that in lieu of the royalty of 10 per cent. now paid to the Post Office on their gross receipts, the companies would undertake to make good to the Department any loss which the local telegraph revenue might suffer from the development of telephonic communication within such district. In estimating the telegraph revenue account was to be taken of its normal growth, by estimating what had been its growth during the previous three years. The second proposal contemplated that the existing royalties should be reduced from 10 per cent. to 5 per cent.; that the same guarantee as that contained in the first proposal should be entered into; that the existing radius for exchange licences, which is now generally fixed at from four to five miles, should be extended to fifteen miles; and that various other restrictions should be removed, which would in almost all essentials give the same freedom as that embodied in the first proposal. Before describing the third proposal, I think it may conduce to a clear understanding of the question if I at once proceed to state why I have come to the conclusion that the existence of such a guarantee as that which I have just described is inadmissible. At first sight I was a good deal attracted by it, and I thought it might offer a solution of the question. When, however, I examined the proposal further I came to the conclusion that with such a guarantee there were associated some very serious and, indeed, insuperable objections. If it were accepted a monopoly would at once be conferred, so far as each locality was concerned, upon the particular company which gave the guarantee, for it would obviously be unfair to accept a guarantee unless the guaranteeing company were secured against competition. I think the opinion will be generally accepted that if there is to be a monopoly it had better be in the hands of the Government, who can be controlled and who are directly amenable to public opinion, than in the hands of a private company [hear, hear]. Besides this objection there was another which, even if it had stood alone, would, in my opinion, be quite sufficient to prevent the idea of a guarantee from being entertained. If the Post Office had once accepted the principle of such a guarantee its discretion would have been fettered in introducing any change in the telegraph tariff. The third proposal of the companies contemplates no guarantee, and proposes that the existing royalty of 10 per cent. should continue to be paid, and that similar modifications to those I have already referred to under the second proposal should be made. I may further state that great stress was laid by the companies in all the proposals submitted to me upon the abandonment of the condition contained in all recent licences that the companies should furnish the Post Office with an unlimited supply of any patented instruments used by them. As already stated, I cannot accept the principle of a guarantee, which is an essential feature of the first two proposals. I have, however, come to the conclusion that the third proposal, an essential feature of which is the continuance of the existing royalty of 10 per cent., affords a basis for a settlement, and the terms the Government have decided to offer are the following:—(1) That the Government should reserve the right either to carry on telephone business itself or to give licences to any responsible persons to carry on such business in any part of the country, whether any previous licence has been granted for such part of the country or not. (2) That the condition that the companies should furnish the Post Office with an unlimited supply of any patented instruments used by them should be abandoned. (3) That as the extension of the radius to 15 miles asked for by the companies would involve in principle just the same objections as fixing the radius as at present at four or five miles, no limitation of radius should be maintained. (4) That with the abolition of any limit of radius and consequent extension of areas the distinction between the conditions on which the companies have hitherto been allowed to use trunk and exchange wires will not be maintained, the companies being in future able to provide themselves with trunk and exchange wires alike. (5) Call offices should be allowed for the transmission of oral communications. (6) Having regard to these concessions, and to the desirability, as far as possible, of securing simplicity of accounts between the Post Office and the companies, the royalty of 10 per cent. now paid on gross receipts should be extended to their receipts from private wires. (7) That the Post Office incurs no obligation to provide way-leave or to erect wires for the companies. (8) That, in order to maintain the distinction between written telegraphic messages and the spoken communications made by means of the telephone the telephone companies shall not accept or deliver any written message at any point. I think it will be seen that, so anxious have I been to redeem the pledge that no unnecessary impediment should be thrown in the way of the public enjoying the advantages of telephonic communication, in some respects I have conceded more than has been asked for either by the companies or by the public [cheers]. I can only say that I hope the terms will be received in the spirit in which they are offered, and if they should be unreservedly accepted as a settlement of the question it is only necessary for me to add that as soon as the existing licences are returned they shall be amended so as to carry out the foregoing proposals; and that in all new licences which may be granted the terms just described will be embodied [cheers].

Mr. JACOB BRIGHT thought that the arrangement proposed by the Postmaster-General, which appeared to be as just as it was generous, would be satisfactory to the persons in Manchester who were interested in the subject [hear, hear].

Mr. GRAY said the statement of the right hon. gentleman was highly satisfactory and exceedingly clear. He quite agreed with the provisos relating to the protection of the public and the Department, and did not think it would be wise to go back over old controversies. If the right hon gentleman, when he said that there was no obligation on the part of the Department to erect trunk wires for the telephone companies, meant that he would not erect them, the result would be such as the right hon. gentleman in his present frame of mind did not contemplate. It was impossible for any company, or any private individual, to run wires from town to town, because the Post Office had obtained a monopoly of way-leaves along the railway lines. If the right hon. gentleman meant that the Post Office would not erect them unless it would be for the convenience of the public he had no objection to that; but if the right hon. gentleman meant that the Post Office would not do so in any case he would shut out the public from a great convenience. The companies were not desirous to secure revenues from trunk wires, but only that those who used telephones in towns should have facilities for communication between town and town. What he wanted from the right hon. gentleman was some assurance that he would not draw a hard-and-fast line which would deprive the public of the United Kingdom of an advantage which the public of every civilised country either had already or were about to have—namely, that of carrying on conversations with people living in towns at a considerable distance. Let the right hon. gentleman make all the profit he could, but let him not, because he had a monopoly, prevent the public from deriving any advantage from a great discovery. The right hon. gentleman proposed, in consideration of the undoubtedly substantial and generous concessions which he enumerated, that the Post Office should receive a royalty upon private wire business. That involved a principle which the companies might have some difficulty in acceding to. The right hon. gentleman might as well ask an individual who ran a private telegraph wire to give him a royalty on it. [Mr. Fawcett: If he got a profit from it.] The right hon. gentleman might as well ask him for a royalty on a house, if he had one and let it at a profit rent. The right hon. gentleman said that telephone companies must not be permitted to transmit anything in the nature of a written message. That was a condition scarcely worthy of the position which the Government had now taken up. At present the Post Office had a certain number of telephone exchanges, and any person subscribing to them had two privileges which the Post Office refused to subscribers to private telephone exchanges, and one of these was the sending of a written message. He did not see why the right hon. gentleman should deprive subscribers to the telephone exchanges of that advantage. The policy of the Department ought to be confined, in the first place, to protecting the public against the evils of monopoly; and, in the next place, protecting the revenue of the Department against loss. But granting these two points the policy of the Department ought to be not to interfere in any way with the services which the public might otherwise receive. He suggested that telephone companies who wrote telegraphic messages for their subscribers should charge the rate which the Postmaster-General himself charged in connection with his own telephone exchanges, for similar services, and that such messages should be held to partake of the nature of telegrams, and that the revenue derived from them should be the property of the right hon. gentleman in his official capacity. Subscribers to the Post Office telephone exchanges could dictate a telegram through the telephone. Why, he asked, should not the same facility be given to all who use telephone exchanges? The charge of five guineas which must now be made before the privilege could be secured was preposterous. The proposals of the right hon. gentleman were, on the whole, very fair, and if fully carried out would be very beneficial to the public.

Mr. ARNOLD, feeling convinced that the use of the telephone would largely increase, hoped that the development of the invention would be entrusted to those who could develop it most cheaply for the public.

Mr. PULESTON thanked the Postmaster-General for the liberal concessions he had made. The right hon. gentleman need not be afraid that such concessions would militate against the revenue of the telegraph service. In America it had been found that in proportion as facilities had been given for the use of the telephone the revenue of the telegraph service had increased. So it would be here.

Mr. MACLIVER also joined in the expression of satisfaction at the Postmaster-General's statement.

Dr. CAMERON did not desire to enter into old controversies. He could not, however, help saying that if the Government had a legal right, they had scarcely a moral right to an exclusive right in the telephones. It therefore behoved the Government to treat the telephone companies so that they might as nearly as possible be in the position that they would have occupied if this right had not been maintained by the law courts. He hoped that before long the Postmaster-General might be able and willing to reduce the royalty of 10 per cent. which the telephone companies were now charged [hear].

Mr. GRAY said that the telephone companies, in asking that the royalties should be reduced from 10 per cent. to 5 per cent., intended immediately to give the amount of the reductions to their subscribers.

Mr. FAWCETT said that nothing could be more kindly than the way in which the hon. member for Carlow had spoken of him personally, but the hon. member appeared to draw a distinction between the Post Office officials and himself. He did not think anything could be more unfair to the heads of a department than that he should let such a distinction be drawn. He took upon himself absolutely and unreservedly the responsibility for everything that had been done [hear, hear]. He did not mean to say that there had been no mistakes and no delay; but his short sketch of the matter would show that it was an extremely difficult one to deal with, and for any mistake or delay he hoped the hon. member would blame the Postmaster-General, who was responsible to Parliament, and not the officials of the Post Office, who worked with great zeal to serve the public to the best of their ability. In saying that no obligation should be imposed upon the Post Office to erect wires, or secure private way-leaves, he did not mean to say that in no circumstances whatever would the Post Office erect wires, or obtain way-leaves at a proper rent; but a public department that had paid a heavy sum for the wires that passed along railways, was bound to consider the public interest, and it was therefore bound to deal with each application strictly on its merits. As to whether any greater facilities could be afforded for allowing messages which were sent in the first instance by telephone to be

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forwarded by telegraph wire, although he did not see his way to this at present, he would look into the matter. He recognized as a general principle that all he had to do was to afford the utmost possible facilities to the public, with due regard to the protection of the revenue. On the subject of the royalty, he would remark that a Government monopoly must be taken with its disadvantages as well as its advantages; and it was not necessarily an objection to it that any part of the service might be done more cheaply, otherwise it might be alleged that injustice was done if a company were refused permission to deliver letters in London at a halfpenny each. It was not proposed to make any charge for telephone call messages; they would be allowed on the understanding that the companies handed over 10 per cent. of their receipts. The proposal that this should be extended to private wires was pressed, not so much for increasing the revenue as for simplifying the accounts. He did not see his way to making any exception in the case of written messages; the essential distinction must be maintained; it would make a serious difference in the revenue if written messages were allowed. If the companies would accept those terms as a final settlement and unreservedly, there was no reason whatever why their licences should not be amended at once; and equal promptitude would be shown in granting any new licences.

Mr. PULESTON said the right hon. gentleman had disavowed any responsibility in the procuring of way-leaves; but he understood that that was one of the greatest obstacles to telephonic development. Would it not be advisable to consider whether the Post Office might not be authorised to exercise compulsory powers in some cases? ["oh."] There ought to be some plan of reducing the difficulty now experienced in obtaining way-leaves.

Mr. GRAY said that in some cases the only communication between town and town was along railway lines.

Mr. FAWCETT said that while it would be very unwise to give the assurance asked for, he might say that everything would be done on the part of the Department to prevent unnecessary delay. With regard to the important question of way-leaves on railways, the Government were bound not to grant such a number as to cripple the business of the Department. They were therefore bound to proceed with extreme caution, but he could assure the hon. member that each case would be considered on its merits [hear, hear].

Mr. T. O'CONNOR asked whether the right hon. gentleman would have any objection to supply telephonic communication between different parts of that building, because at the present moment it was easier to ascertain what was going on in that House in a newspaper office in Fleet-street than in the library of the House of Commons.

Mr. FAWCETT replied that that was a matter under the control of the First Commissioner of Works, and not of the Postmaster-General.

The vote was agreed to.

LEGAL.

The Postmaster-General v. The Cambrian Railways Company.

This case came before Mr. Baron Pollock and Mr. Justice Lopes, in the Queen's Bench Division of the High Court of Justice on the 7th instant.

The SOLICITOR-GENERAL said this was an action for damages in consequence of the company not having given free passes to the officials of the Postmaster-General, who were required to examine the telegraph wires along the lines. The plaintiff recovered judgment for damages and costs, and there was an order that the passes should be granted, but this order not having been complied with, the present motion was to enforce compliance by sequestrating property of the company. It now appeared that a receiver had been appointed, and therefore a sequestration could not be asked for; but some of the officials of the company might be attached for disobedience to the order of the Court. He should be reluctant to do this, and he therefore asked that the matter might stand over, to see if an arrangement could be come to.

Mr. CHANNELL, for the defendants, said there was no wish to disobey the order of the Court, and he believed there would be no difficulty in coming to an arrangement.

The case was ordered to stand over.

Re South Eastern (Brush) Electric Light and Power Company (Limited).

In the Chancery Division of the High Court of Justice, on Saturday last, Mr. Justice Chitty heard the petition of this company for leave to reduce its capital, which was stated to be £100,000. There had been taken up 400 £5 shares, which were fully paid up, and there were 19,600 upon which £2 a share had been paid. It was proposed to keep the fully paid-up capital in its present position, and reduce the remaining shares to £2 10s. each, which would leave only 10s. at call on each share. This would reduce the capital of the company to £51,000. The creditors of the company had given their assent to the reduction.

Mr. Romer, Q.C., appeared in support of the application.

His lordship said he would assent to the reduction, which was, however, very large; but as all the creditors assented he would not object. He directed the reduction to be advertised, so that the public would know that such a reduction had been made.

COMPANIES' MEETINGS.

The Cuba Submarine Telegraph Company (Limited).

The twenty-sixth ordinary general meeting of the shareholders of this Company was held on Wednesday, at the offices of the Company, No. 61, Old Broad-street, Mr. Joaquin de Mancha (Chairman) presiding.

Mr. JAMES SCOTT (the Secretary) read the notice convening the meeting, and the report was taken as read.

The CHAIRMAN: Before moving "that the report and accounts for the half year ending June last be received and adopted," perhaps I had better call your attention to two or three facts. I have no doubt you have studied the report, as you have received it now for some days, and I hope it is as satisfactory to you as it is to us. The State of Cuba, as you all know, has not been very prosperous. They depend very much upon their sugar, which this year has been at a very low ebb, and consequently all business in the island has suffered. Notwithstanding that, however, we have been able to show you a very good result. Besides this you will have seen that the cables have been very satisfactorily repaired by Mr. Keith, to whom we owe a large debt of gratitude [applause]. We owe him a debt of gratitude for the trouble he has taken with the work. You will see that we have paid the half-yearly payment for the new cable, which amounts to £2,000; and at the same time, in addition to putting to the reserve fund its annual interest of £1,383, we have been able to put £1,266 5s. to the reserve fund, which stands at £58,000, and which I am sure you will all consider satisfactory [applause]. We hope that this will still go on increasing, which will be a source of satisfaction not only to the preference shareholders, but also to the ordinary shareholders, for the more money we have in hand to meet any fault in our cables it makes our shares so much the more secure. The accounts, as you all know, we rather pride ourselves on making explicit, and they require very few words on my part to explain them. At the same time, if any gentleman would like to have any information I shall be very glad to afford it. I shall now move "That the report and accounts now submitted be received and adopted" [applause].

Mr. ALEXANDER F. LOW: I beg to second that.

Mr. GRIFFITH observed that it was usually a good sign that a Company was prosperous when the meeting was small in numbers, because it showed that confidence was felt in the directors. He did not rise for the purpose of criticism, because there was no ground for it, but as he had recommended the Company to his friends, perhaps the Chairman would be kind enough to give him a little information on one or two points. He said that they were paying a rent for their cable, which still continued to be one of the sources of expenditure. He should feel obliged if the Chairman would tell him for how many years they would have to pay rent upon that cable. He thought it was a most fortunate thing that they were able to buy a new cable upon such a system. The next question was—What was the amount of the tax which the Spanish Government still unfairly detained? It had been due to the Company for a long time, and it did not reflect very much credit on so important a Government as that of Spain to avoid paying its just debts. There was a third question, which was, perhaps, of a minor character. There was an item of "Loan on Securities, £1,500." He had no doubt that the securities were very good, and that the interest also was good, but still it would be a satisfaction to be assured that the loan was an advantageous one and the security good. He wished to be well informed on all subjects connected with the Company, so that he might be able to speak favourably of it when opportunity offered.

The CHAIRMAN, in reply, said the cable that they were paying for gradually was originally contracted for at £48,000, and they had to pay every year £4,000 whilst it was working. There were still nine years more to run before the whole was paid, but in case of any defect the contractor was bound to make the cable good, otherwise the payment ceased. They had now paid off £13,457. Therefore there was still outstanding £34,000 odd. They did not take this from the reserve fund, but paid it out of the earnings of the Company. They thus got a new cable, they might say, for nothing, for if the cable were to break down at any moment, the contractor was bound to repair it. In order to secure his doing so, they retained a certain portion of the money that should be paid, so as to form a fund in case of necessity. They had thus reserved £5,000, so that in case he did not do the work himself, and that they should undertake it themselves, they had no further payment to make. The other question was with regard to the tax they were to receive from the Spanish Government. They had fought the matter out both at Cuba and Madrid, and the Government had given orders that the money should be paid. The whole amount was only about £1,000, and they had the last royal order given by the Government that Cuba should pay the money. When they applied at Havannah for the money they were told that the order would be obeyed, but that it was not included in the last year's estimates, so that they were unable to pay it. But they promised to pay it, and the directors had no doubt that as soon as the new estimates came in their £1,000 would be paid. Cuba had not been in a flourishing state last year. They were told that sugar had been so cheap that they were not selling it, but using it as manure. They would see that the price of sugar was as low as 13s. The next question asked was about the £1,500 loan. That was a portion of the money they had on hand that came in from one source or another, and as they did not require it immediately for paying dividends or anything else, they lent it on the Stock Exchange on good security from fortnight to fortnight. The interest they received, he was sorry to say, was not very flourishing. He thought in one case they had not been getting more than 1½ per cent. per annum, but it was better than the money being in the hands of the bankers earning nothing. This

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money would be called in in a few days to pay their dividends. As they would see by the note, he thought this was the only Company so frank as to give the names of the parties with whom it deposited money. They got 5 per cent. upon all those sums, which he thought was very satisfactory [applause].

Mr. KEENLYSIDE wished to ask a question. Their reserve now stood at the satisfactory sum of £58,000. He had been a shareholder a great number of years, and had always been a steady supporter of increasing the reserve. This sum would soon reach £60,000, which was the amount of their preference capital. He should like to ask whether the directors might not think it safe to allow simply the addition of the 5 per cent. every half year, instead of taking any more out of the profits of the half year [hear, hear]. Of course, if they had a prosperous half year, he would be happy to see a few more thousand pounds added to it. The 5 per cent. would bring it up to within £530 of the £60,000 next half year. And if they were able, as he hoped they would be, to increase the reserve to £60,000 when they met again, he should like to know if the directors would not consider that £60,000, plus the interest, would be enough? There was one other question he would like to ask. He saw in the accounts an item of agents near the Spanish Government. It had always appeared a rather singular way of putting it, and he wished to know whether that was likely to continue.

The CHAIRMAN replied that when the time arrived the directors hoped to take into consideration whether it would be advisable to leave the reserve fund at £60,000 or at any other sum. But they knew that cables were very ticklish things; they were not like other property that they could readily repair. When they had to repair the cable before it cost something like £21,000. Therefore the Board had to consider that the property might suffer great deterioration, and that, perhaps, they might have to relay the whole cable, so that the stronger their reserve fund was the better. They hoped to be able to pay 10 per cent. by and by, and then stop there and add everything to reserve. It was well to have plenty at the bankers. He remembered hearing a tale about Rothschild. He was asked how a man felt when he had six millions of money. He said he felt he could pay his debts in full [laughter]. If then they could pay their twenty shillings in the pound, and have enough money in hand to relay the whole cable through, it would be satisfactory to them. The other question was about the gentleman attached to the Spanish Court. He thought he explained last time that this was one of the charges they were bound to keep up. It was requisite to have representatives in Madrid and Cuba. If there were any difficulty, and they had to make a claim, they pushed it through the offices. It cost a little money to clear the way, so that the thing should be done; otherwise, if they had claims in Spain, as they knew was the case in London or anywhere else, if they had not the entrée to the office, things were put into the pigeon-hole. It was only a small matter of £200, and it was well spent in having representatives to carry the business through.

The CHAIRMAN then put the resolution, which was carried unanimously.

The CHAIRMAN next proposed :—"That dividends for the half year be now declared on the shares of the Company, at the rate of 10 per cent. per annum, subject to income-tax on the preference shares, and 9 per cent. per annum, free of income-tax, on the ordinary shares, payable on and after August 14th inst."

Mr. LOW seconded the resolution, which was put and agreed to.

The CHAIRMAN then proposed the re-election of Mr. Horatio J. Perry as a director of the Company.

Mr. GRIFFITHS seconded the resolution, which was carried.

The auditor, Mr. Greenwood, was re-appointed, and a vote of thanks to the Chairman and Directors, the Secretary and Mr. Keith, closed the proceedings.

The National Telephone Company (Limited).

The fourth annual general meeting of the shareholders of this Company was held at the offices of the Company, 11, Queen Victoria-street, E.C., on Friday, the 8th inst., Colonel R. Raynsford Jackson in the chair.

Mr. W. B. CAMPBELL (the Secretary) read the notice convening the meeting. The reports and accounts were taken as read.

The CHAIRMAN said: Gentlemen, you have all, I think, carefully examined the report, and you will have seen that the business of the Company has during the past twelve months progressed satisfactorily; that there has been a large increase in the revenue, and that we have been enabled to pay an increased dividend to the ordinary shareholders. I see every indication of a further development in the same direction, and there are signs that during the current year there will be a considerable increase of net revenue, which is the important point with the shareholders. I do not intend to dwell upon the past history of the Company, or upon the character of its business. I wish to call your attention, however, to one paragraph in the report, which bears upon our relations with the Postmaster-General, and you will see that the directors made use of the following words :—"They are glad to be able to inform the shareholders that the Postmaster-General is considering proposals made to him on behalf of the companies, and that they indulge the anticipation of a result according with what might reasonably be expected from the well-known breadth and liberality of his views." Last night, in the House of Commons, the Postmaster-General gave his answer to a letter sent to him by the chairman of the United Telephone Company on behalf of the telephone companies who are working in association with that important company. In that letter various requests were made, some of which were alternative. The answer given by the Postmaster-General is satisfactory upon many points, and shows that your directors were not mistaken in assuming that he would deal broadly and liberally with the important questions that were brought under his review. I have, however, to criticise two of the headings of his answer, and to suggest that modifications should be made in them. I recall your attention first to his answer No. 6, which is as follows :—"Having regard to these concessions, and to the desirability, as far as possible, of securing simplicity of accounts between the Post Office and the companies, the royalty of 10 per cent. now paid on gross receipts should be extended to their receipts from private wires." Now, I apprehend that the Postmaster-General has made this suggestion without duly considering all the bearings of the case as they relate to the business of the companies. The Postmaster-General, under the Telegraph Acts, has the monopoly of a certain kind of business, but he has no control over other kinds of business. When he grants to the companies a licence to do that business, which is his monopoly, he has a perfect right to accept a royalty upon it; but, in the case of companies doing business over which he has no control, I think that the Postmaster-General cannot expect a royalty, and for this reason—if the companies who do that business which cannot be done without the Postmaster General's licence pay him a royalty upon the business which any private firm, or anybody not possessing his licence, can do, the effect must necessarily be that the companies holding the Postmaster-General's licence will labour under great disadvantage when they attempt the private wire business which any private person can do without his licence. The private firms, not possessing the license, could do the business cheaper than the companies. Therefore, the effect of submitting to this condition would be that the private and other unlicensed firms would do all the particular class of business which can be done without his sanction, or without infringing his monopoly [hear, hear]. Mr. Fawcett is so fair minded that I think that when this view of the case is put before him he will withdraw that clause No. 6. Then his eighth condition is: "That in order to maintain the distinction between written telegraphic messages and the spoken communications made by means of the telephone, the telephone companies shall not accept or deliver any written message at any point." I think the wants of the public can be met without in any way infringing the Postmaster-General's condition which I have just read; but no scheme will be complete, or can be ultimately satisfactory to the public, which does not provide for exchange subscribers of the companies being able to send telegraphic messages through the Postal Telegraph Office; and therefore I suggest that the Postmaster-General should allow the various exchanges erected by private enterprise to be connected with the Postal Telegraph Office, and that the subscribers should be permitted to send, through wires which could be switched into operation when required, messages to the Postal Telegraph Office to be transmitted as telegrams, so that there would be no delivery of written messages by the companies, but there would be a great increase of business to the Postmaster-General through the instrumentality of the various companies' exchanges. In addition to giving subscribers the privilege of sending Post Office messages through the Postal Telegraph Office, the Postmaster-General should also, when he receives such messages for the Telephone Exchange subscribers, deliver these messages through the exchange to the subscribers. That would be an immense boon to the mercantile community and to all those who desire rapid communication with their connections in the various business centres; and I do not think that unless a provision is made to supply this particular want the general scheme of the Postmaster-General can be considered complete [hear, hear]. Speaking for myself, and as representing our own Company, I have no other criticisms to make upon the scheme of the Postmaster-General, and it must be distinctly understood by the shareholders that I speak for no one else. I have had no means as yet of communicating with the representatives of the other telephone companies, but I cannot think that their decision will be very different to my own. There is no doubt, as I said before, that the Postmaster-General has aimed at dealing liberally with this question, and has shown an earnest desire to enable the public to derive that benefit from the telephone to which it is justly entitled. I trust that the effect of the correspondence which is going on between the Postmaster-General and the representatives of the companies will be finally to satisfactorily solve this very difficult problem. To make my meaning more distinct with reference to the disadvantage of paying royalty upon private wire business, I must explain that my remarks do not apply to all kinds of private wire business. There is a certain branch of private wire business which forms part of the Postmaster-General's monopoly, and there is another part which does not. That part which falls under the Postmaster-General's monopoly he is entitled to royalty on, but it is that part of the private wire business which does not infringe the Postmaster-General's rights that the remarks I have made apply to. I think it unnecessary to say more, and I will now move the adoption of the report and accounts.

Mr. JOHN P. BIGELOW (the vice-chairman) seconded the motion, which was put, without discussion, and carried unanimously.

The CHAIRMAN moved the re-election of Mr. Peter Garnett, of Thirsk, Yorkshire, as a director.

Mr. W. A. SMITH seconded the motion, and it was carried.

The CHAIRMAN also moved, in succession, the re-election of the other retiring directors, Mr. Samuel H. Sands, of Nottingham, and Mr. John Frederic Harrison, of Rawdon, Yorkshire.

The motions were seconded by Mr. SMITH and Mr. BIGELOW, and were adopted.

The CHAIRMAN: I wish to make an observation with reference to the auditors. The United Telephone Company has the right to appoint an auditor to audit the accounts of all the subsidiary companies. Mr. Blease is the auditor so appointed, and he has, on behalf of the United Telephone Company, examined our accounts and expressed his satisfaction with them. In future his name will appear with those of Messrs. Quilter, Ball, and Co., in our report and accounts.

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Mr. Bolland proposed the re-election of Messrs. Quilter, Ball, and Co., as auditors.

Mr. Smith seconded the proposition, which was carried.

A vote of thanks was passed to the chairman, who, in acknowledging the compliment, expressed the belief that when they met again he would have a much better record to place before the shareholders, although the present one was not unsatisfactory.

The meeting then closed.

The Lancashire and Cheshire Telephonic Exchange.

The third annual general meeting of the shareholders of the Lancashire and Cheshire Telephonic Exchange Company (Limited) was held on Monday, at the offices of the Company, Faulkner-street, Manchester, Mr. Charles Moseley, Chairman of the Board of Directors, presiding. The following is the report:—The Directors have the pleasure to submit herewith their third report and statement of accounts, and trust the results shown therein will be satisfactory to the shareholders. The subscriptions and rentals (including those of the out-districts) pertaining to the financial year amount to £53,256 3s. 4d., as compared with £45,544 12s. 2d. for the year ending 30th June, 1883. The amount of income carried forward to next year's revenue, as representing sums received in advance for periods extending beyond 30th June, 1884, is £26,101 6s. 11d., against £23,391 5s. in last year's balance-sheet. On the past year's working, and after deducting £496 0s. 6d. loss of rental on Trunk lines between towns, the net profit is £18,655 17s. 7d., which, with a credit balance of £2,073 4s. 6d. remaining from last account, makes a total fund of £20,729 2s. 1d. Out of this sum an amount of £8,613 10s. 2d. has already been absorbed in the payment, in January last, of an interim dividend; and the directors now recommend a further dividend of a like amount, making a complete dividend of 6 per cent. for the year ending 30th June, 1884. After providing for this dividend there will remain at credit of profit and loss account a balance of £3,230 15s. 4d., which is carried forward to next year. On 30th June, 1883, the total number of subscribers to the various exchanges was 2,359 and of private renters, 697; this year, on the same date, the figures were 2,734 and 828 respectively. As regards the money value of this increase, it may be stated that on 30th June, 1883, the business (including work not finished) represented orders on the books equalling a gross income of £54,498 3s. 8d. per annum, and on 30th June, 1884, £61,149 0s. 6d., showing a nett increase of new business to the extent of £6,650 16s. 10d. When comparing this progress with the year ending 30th June, 1883, it should be remembered that during the past 12 months considerable reductions have been made in the charges at several of the district centres, with a view to encourage their development. There is a steady increase in the average of daily "calls" made by subscribers, which may be taken as evidence that the many facilities offered by the telephone system are being appreciated more and more for business and domestic purposes. With a view to improve the service at Liverpool, an entirely new switching apparatus has recently been purchased, subject to a three months' trial; and it is believed that the exchange system in that town is now the most rapid and efficient which has hitherto been practically applied for telephonic purposes. The retiring directors are Messrs. Moseley, Heyworth, and Agnew, who are eligible for re-election. The accounts have been audited by Mr. C. R. Trevor (Trevor and Pilling) on behalf of this company, and by Mr. R. S. Blease (John S. and Robert S. Blease and Sons) on behalf of the United Telephone Company. The Company's auditor, Mr. C. R. Trevor, retires, but offers himself for re-election, for which he is eligible.

The Chairman, in moving the adoption of the report and statement of accounts, said it was a matter of great satisfaction to the directors that, in spite of all the difficulties they had had to encounter, the result of the year's working left them a fair profit, and enabled them to declare a dividend, while at the same time they confessed to a feeling of disappointment that they had not been able to extend their business and increase their profits in the proportion they anticipated from the important property over which they had control. The difficulties with which they had had to contend arose principally from the restrictions which had been imposed upon them by the Post Office. The Post Office had, of course, to consider from an official point of view the interest of the telegraphs, but in the opinion of men who had a knowledge of the subject, and who were fairly competent to anticipate what the result of the development of the telephone would be upon the revenue of the telegraphs it would appear that the conclusions of the Department and the anticipations of the officials were altogether wrong. The telephone itself was used in a sphere altogether out of the action of the telegraph. It supplied a want to business people which it was impossible to obtain by the telegraphs, and yet the Post Office had not hesitated up to the present time to hamper the telephone companies, to restrict them and to tie them in their operations and extensions in every possible way that suggested itself to their ingenious minds. The question had been laid before the Post Office in every conceivable form, and the Directors had been in negotiation with that Department continuously; in fact, one-half of the time of the Board had been taken up in discussing the subjects which formed the bones of contention between the Company and the Department, instead of using their energies for the development of the business. After long and harassing correspondence and negotiations, in which the Directors had not been influenced by selfish motives, but by the interests of the public, no relief could be obtained from the Post Office officials, and the Directors then determined to submit the whole case to the House of Commons. The city and county members of Parliament gave them their assistance in putting questions to Mr. Fawcett, the Postmaster-General, and the result was that that gentleman requested the telephone companies to put their proposals in a definite and practical form, when he promised that they shoul[d] receive his careful consideration. A letter of proposals agreed upon b[y] the various companies was accordingly submitted to Mr. Fawcett, and o[n] Thursday last he gave his reply to the proposals and what he thought wa[s] a solution of the vexatious questions at issue. That these proposals of Mr. Fawcett were extremely liberal as compared with the previous policy the[re] could be no doubt, but one of his proposals, to place a royalty of 10 p[er] cent. on private wires which did not come under the jurisdictio[n] of the Post Office, would operate most unjustly, and the telephon[e] companies hoped that he might be induced, on further consider[a]tion, to withdraw it. Referring to the report, the Chairman sa[id] the gross income during the year had been £61,149 0s. 6d., a[n] increase of £6,650 16s. 10d. over the previous year. The amoun[t] of new business for the year was £9,750. The revenue was £53,256 3s. 6d. and after carrying forward £26,101 6s. 11d., and meeting sundry losse[s] this left a net profit of £18,655 17s. 7d., which, added to a sum o[f] £2,073 4s. 6d. carried forward from last year, gave a sum of £20,729 2s. 1d. at the disposal of the directors. Out of this they recommended the pay[-] ment of a dividend of six per cent., leaving a balance of £3,230 15s. 4d. in hand. The maintenance of lines during the year had cost £5,716 4s. 8d. and £21,869 had been spent on plant account, including an expenditu[re] of between £4,000 and £5,000 on the establishment of a new route fro[m] Manchester to Liverpool. The total number of exchange subscribers [is] now 2,734, an increase on the year of 475; and of private subscribers 828, an increase of 131. During the year 748 miles of additional wire ha[d] been fixed, making the total length of the company's wires 3,628 miles. The number of messages passing through the company's switch room[s] had increased during the year by 1,076,610, and the total number for th[e] year was 5,812,634. The whole of the lines and property of the compan[y] were now in as good condition as they could possibly be. In conclusion he moved the adoption of the report and accounts.

Mr. Turner seconded the motion, which was unanimously agreed to.

The dividend recommended by the Directors was declared, and th[e] retiring Directors and officers of the Company having been reappointed, a vote of thanks to Mr. Moseley for presiding brought the meeting t[o] a close.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Aug. 13.		Business Done Week Ending Aug. 13. Highest.	Lowest.
Anglo-American	31⅛,	32⅛	32⅛	31⅝
Do. Preferred	55½,	56½	57	55⅝
Do. Deferred	7,	7½	7 3-16	7
Brazilian Submarine	9⅞,	10⅛	10	—
Cuba	10¾,	11¼	—	—
Do. Preference	17,	18	—	—
Direct Spanish	4½,	5	—	—
Do. Preference	14¾,	15¼	—	—
Direct United States Cable	9¾,	10	10	9¾
Eastern Telegraph	11⅛,	11⅝	11¼	11 1-16
Do. 6 per Cent. Preference	13¼,	13¾	13⅝	13½
Do. 5 per Cent. Debentures, 1899	102,	106	103	—
Eastern Extension	11⅜,	11⅝	11⅝	11 7-16
German Union	9¼,	9¾	9½	9⅜
Globe Telegraph and Trust	6¼,	6¾	6¾	6⅝
Do. Preference	12½,	12¾	12⅝	12 9-16
Great Northern	13½,	13¾	13¾	—
Indo-European	31½,	32½	32	31¾
Reuter's	8,	8½	—	—
Submarine	165,	175	—	—
West India and Panama	⅞,	1⅛	—	—
Do. 1st Preference	6¾,	7¼	7	6 13-16
Western Brazilian	6,	6½	6⅛	5⅞
Western Union 7 per Cent. 1st Mortgage	123,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	3-16,	5-16	¼	—
Oriental	⅛,	⅜	⅛	—
United Telephone	11¼,	11¾	11⅞	10 7-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1¾,	2	1 15-16	—
Do. (fully paid)	3½,	4	3 9-16	3 7-16
Hammond Light (£3 15s. paid)	⅜,	⅝	7-16	—
Swan	—	—	—	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	33,	34	34	33
India Rubber, Gutta Percha, and Telegraph Works	22,	23	22⅝	22¼

CIVIL SERVICE COMMISSION.—EXAMINATION for ASSISTANT EXAMINERSHIPS in the Patent Office (21-25), 29th August. Salary £250 to £400.

The date specified is the latest at which applications can be received. They must be made on forms to be obtained with particulars from the Secretary, Civil Service Commission, London, S.W.

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23	·024	·60960	576·	·37161	·00045239	·29186	[illegible]	1·7425	2·5975	573·89	172·167	·36498	17·455	57·291	[illegible]	17·462	10·017	45·458	23
24	·022	·55880	484·	·32697	·00038013	·25680	10·249	1·4642	2·2855	682·98	204·894	·43754	20·773	48·140	·068153	14·673	14·187	64·352	24
25	·020	·50800	400·	·25806	·00031416	·20268	8·4705	1·2100	1·8034	826·40	247·920	·55450	25·135	39·785	·082465	12·126	20·772	94·218	25
26	·018	·45720	324·	·20903	·00025446	·16417	6·8611	0·98015	1·4612	1020·3	306·09	·68441	31·031	32·226	·10181	9·8224	31·659	143·27	26
27	·0164	·41656	268·96	·17352	·000211241	·13628	5·6955	·81365	1·2129	1229·0	368·70	·82447	37·381	26·751	·12265	8·1538	45·943	208·40	27
28	·0148	·37592	219·04	·14131	·000172034	·11099	4·6384	·66263	·98779	1509·1	452·73	1·0123	45·90	21·787	·15059	6·6404	69·270	314·2	28
29	·0136	·34544	184·96	·11933	·000145267	·093719	3·9167	·55953	0·83391	1787·2	536·16	1·1992	54·358	18·397	·17834	5·6072	97·148	440·66	29
30	·0124	·31496	153·76	·098865	·000120763	·077910	3·2561	·46515	·69340	2149·9	644·97	1·4422	65·388	15·294	·21453	4·6614	140·57	637·63	30
31	·0116	·29464	134·56	·086811	·000105683	·068181	2·8495	·40707	·60681	2456·6	736·98	1·6479	74·718	13·384	·25414	4·0793	183·55	832·57	31
32	·108	·27432	116·64	·075250	·000091609	·059102	2·4700	·35286	·52600	2834·1	850·23	1·9012	86·197	11·602	·28280	3·5360	244·29	1108·0	32
33	·100	·25398	100·00	·064515	·000078540	·050670	2·1176	·30252	·45090	3305·6	991·68	2·2175	100·541	9·9463	·32986	3·0316	332·34	1507·5	33
34	0·0092	·23368	84·64	·054605	·000066476	·042887	1·7924	·25605	·38169	3905·5	1171·65	2·6199	118·79	8·4185	·38972	2·5659	463·91	2104·3	34
35	·0084	·21336	70·56	·045521	·000055418	·035752	1·4942	·21346	·31820	4684·8	1405·44	3·1427	142·49	7·0181	·46748	2·1391	667·53	3027·9	35
36	·0076	·19304	57·76	·037264	·000045365	·029267	1·2231	·17473	·26047	5723·0	1716·90	3·8391	174·07	5·7449	·57108	1·7511	996·18	4518·6	36
37	·0068	·17272	46·24	·029832	·000036316	·023430	0·9792	·13988	·20853	7148·8	2134·64	4·7956	216·94	4·5991	·71336	1·4018	1554·4	7050·5	37
38	·0060	·15240	36·00	·023225	·000028274	·018241	·7623	·10891	·16235	9182·2	2754·66	6·1597	279·28	3·5087	·91627	1·0914	2564·4	11632·	38
39	·0052	·13208	27·04	·017445	·000021237	·013701	·5726	·081801	·12194	12225·	3667·5	8·2008	371·82	2·6895	1·2199	0·81974	4545·4	20617·	39
40	·0048	·12198	23·04	·014864	·000018095	·011674	·4879	·069700	·10390	14347·	4304·1	9·6245	436·37	2·2916	1·4317	·69848	6260·8	28399·	40
41	·0044	·11176	19·36	·012490	·000015205	·0098097	·4099	·058567	·087306	17074·	5122·2	11·454	519·32	1·9256	1·7038	·58692	8867·0	40221·	41
42	·0040	·10160	16·00	·010322	·000012566	·0081259	·3388	·048402	·072154	20660·	6198·0	13·859	628·37	1·5915	2·0616	·48056	12982·5	58886·	42
43	·0036	·09144	12·96	·008361	·000010179	·0065668	·2744	·039205	·058445	25506·	7651·8	17·110	775·77	1·2890	2·5452	·39289	19786·9	89752·	43
44	·0032	·08128	10·24	·006606	·0000080425	·0051886	·2168	·030978	·046179	32282·	9684·6	21·655	981·83	1·0180	3·2213	·31044	31694·9	143770·	44
45	·0028	·07119	7·84	·005058	·0000061575	·0039725	·1660	·023708	·035355	42181·	12654·3	28·284	1282·4	0·77979	4·2074	·23768	54116·1	245470·	45
46	·0024	·06096	5·76	·003716	·0000045239	·0029186	·1223	·017425	·025975	57389·	17316·7	38·498	1745·5	·5729	5·7267	·17462	100171·5	454380·	46
47	·0020	·05080	4·00	·002581	·0000031416	·0020268	·0847	·012100	·018034	82640·	24792·0	55·450	2513·5	·3978	8·2465	·12126	207719·0	942180·	47
48	·0016	·04064	2·56	·001652	·0000020106	·0012980	·0542	·007744	·011544	129150·	38745·0	86·621	3927·3	·2546	12·885	·077607	507010·0	2300300·	48
49	·0012	·03048	1·44	·000929	·0000011310	·0007466	·0305	·004356	·0064939	229560·	68868·0	153·99	6982·0	·14323	22·907	·043655	1602799·	7370000·	49
50	·0010	·02540	1·00	·0006451	·0000007854	·0005067	·0211761	·0030252	·0045096	330560·	99168·0	221·75	10054·15	·099463	32·986	·030316	3323456·	15075000·	50

The resistances in the above Table are calculated from Dr. Matthiesson's standard (1 mile of pure copper wire of $\frac{1}{16}$in. diameter equals 13·59 ohms or B.A. units at 15·5° C.).

The resistance of pure copper wire increases as the temperature rises about 0·38 per cent. for each degree C., and 0·21 for each degree F.

The **Diameter** (d) of any copper wire equals the square root of its weight (w) in grains per foot multiplied by 6·872

$$d = 6{\cdot}872\sqrt{w} \quad . \quad . \quad . \quad \text{mils.}$$

The **Weight** (w) o any copper wire per foot in grains equals the square of its diameter (mils.), divided by 47·22

$$w = \frac{d^2}{47{\cdot}22} \quad . \quad . \quad . \quad . \quad \text{grains per foot.}$$

The **Resistance** (R) of any pure copper wire per mile at 15·5° C. equals the square of its diameter (mils.) divided into 53085·9

$$R = \frac{53085{\cdot}9}{d^2} \quad . \quad . \quad . \quad \text{ohms at 15·5° C. per mile.}$$

The **Conductivity** (C) of any copper wire is obtained by multiplying its calculated resistance (R) by 100 and dividing the product by its measured resistance (r).

$$C = \frac{R \times 100}{r} \quad . \quad . \quad . \quad . \quad \text{conductivity per cent.}$$

[* *It will be noticed that several of the figures in the decimal places differ slightly from figures given in other tables, but some of these differences may be accounted for by the differences of temperature at which the measurements were taken.*—Ed. *E.*]

Issued with "THE ELECTRICIAN," No. 14, Vol. XIII., August 16, 1884

Supplement No. 5.

Board of Trade Standard Wire Gauge.

TABLE OF RELATIVE DIMENSIONS, LENGTHS, WEIGHTS, AND RESISTANCES OF PURE COPPER WIRE.*

By H. G. CHEESMAN, Eastern Telegraph Company.

No. of B. T. W. Gauge.	Diameter.		Area.				Weight and Length.—Sp. gr. 8·90.						Resistance as Pure Copper at 15·5° C. or 59·9 F.						No. of B. T. W. Gauge.
	Inches	Millims.	Circular mils. (d^2). 1 mil. = ·001 in.	Circular mm. (d^2)	Square in. ($d^2 \times$ ·7854)	Square mm.	Grains per foot.	lbs. per 1000 feet.	Grammes per metre.	Feet per lb.	Yards per lb.	Metres per gramme.	Ohms per 1000 feet.	Feet per ohm.	Ohms per metre.	Metres per ohm.	Ohms per lb.	Ohms per kilogm.	
0000000	0·500	12·700	250000·	161·290	·19635	126·68	5294·0	756·28	1127·4	1·3223	0·39669	0·000887	0·040216	24863·	0·00013194	7579·0	·000053175	·0002412	0000000
000000	·464	11·785	215296·	138·866	·169093	109·09	4559·2	651·31	970·9	1·5355	·46065	·001030	0·046699	21414·	·00015321	6526·9	·000071700	·00032523	000000
00000	·432	10·973	186624·	120·400	·146574	94·562	3951·1	564·44	841·6	1·7717	·53151	·001188	0·053886	18558·	·00017679	5656·4	·000095468	·00043301	00000
0000	·400	10·160	160000·	103·225	·125664	81·072	3388·2	484·03	721·54	2·0660	·61980	·0013859	0·062837	15915·	·00020621	4850·6	·00012982	·00058886	0000
000	·372	9·4487	138384·	89·278	·1086868	70·119	2930·4	418·63	624·06	2·3887	·81661	·0016024	0·072653	13764·	·00023936	4195·2	·00017355	·00078722	000
00	·348	8·8371	121104·	78·094	·095115	61·335	2564·6	366·36	545·88	2·7296	·81888	·0018319	0·033020	12018·	·00027238	3671·4	·00022661	·0010279	00
0	·324	8·2295	104976·	67·724	·0824481	53·191	2223·0	317·54	473·41	3·1489	·94467	·0021124	0·095774	10441·	·00031422	3182·5	·00030158	·0013680	0
1	·300	7·6200	90000·	58·064	·070686	45·603	1905·8	272·27	405·87	3·6730	1·10190	·0024639	0·11171	8951·7	·00036651	2728·4	·00041030	·0018611	1
2	·276	7·0103	76176·	49·145	·0598286	38·598	1613·1	230·44	343·52	4·3394	1·30182	·0029110	0·13199	7577·0	·00043303	2309·4	·00057274	·0025979	2
3	·252	6·4008	63504·	40·970	·049876	32·178	1344·8	192·11	286·38	5·2053	1·56159	·0034919	0·15832	6316·3	·00051943	1925·2	·00082411	·0037381	3
4	·232	5·8927	53824·	34·724	·0422733	27·273	1139·8	162·83	242·72	6·1415	1·84245	·0041199	0·18680	5353·5	·00061285	1631·7	·0011472	·0052036	4
5	·212	5·3847	44944·	28·996	·0352990	22·773	951·74	135·96	202·68	7·3549	2·20647	·0049339	0·22370	4470·3	·00073393	1362·5	·0016453	·007463	5
6	·192	4·8768	36864·	23·783	·0289529	18·679	780·64	111·52	166·24	8·9670	2·69010	·0060153	0·27273	3666·6	·00089480	1117·6	·0024455	·011063	6
7	·176	4·4703	30976·	19·984	·0243285	15·695	655·93	93·708	139·69	10·672	3·20166	·0071587	0·32458	3080·9	·0010649	939·07	·0034637	·015711	7
8	·160	4·0640	25600·	16·516	·0201062	12·980	542·11	77·445	115·44	12·915	3·8745	·0086621	0·39273	2546·3	·0012885	776·09	·0050711	·023002	8
9	·144	3·6576	20736·	13·378	·0162860	10·507	439·11	62·730	93·511	15·941	4·7923	·010694	0·48486	2062·5	·0015908	628·63	·0077293	·03506	9
10	·128	3·2512	16384·	10·570	·0128679	8·3018	346·95	49·565	73·886	20·176	6·0528	·013535	0·61365	1629·6	·0020087	496·70	·012381	·056159	10
11	·116	2·9463	13456·	8·6412	·0105683	6·7868	284·95	40·707	60·403	24·566	7·3698	·016556	0·74718	1338·3	·0024514	407·93	·018355	·083257	11
12	·104	2·6416	10816·	6·9779	·00849488	5·4804	229·04	32·720	48·329	30·562	9·1686	·020692	0·92955	1075·8	·0030497	327·9	·028409	·12885	12
13	0·092	2·3368	8464·	5·4605	·00664762	4·2887	179·24	25·605	38·186	39·055	11·7165	·026199	1·1878	841·85	·0038972	256·59	·046391	·21043	13
14	·080	2·0320	6400·	4·1290	·00502656	3·2429	135·53	19·361	28·862	51·649	15·4947	·034648	1·5709	636·57	·0051540	194·03	·081139	·36804	14
15	·072	1·8288	5184·	3·3444	·00407151	2·6267	109·78	15·683	23·378	63·765	19·1295	·042775	1·9394	515·62	·0063630	157·16	·12367	·56095	15
16	·064	1·6256	4096·	2·6426	·00321699	2·0754	86·738	12·391	18·471	80·703	24·2109	·054138	2·4546	407·40	·0080532	124·18	·1989	·89854	16
17	·056	1·4224	3136·	2·0232	·00246301	1·5890	66·408	9·4869	14·142	105·41	31·6230	·070711	3·2060	311·92	·010518	95·071	·33794	1·5323	17
18	·048	1·2192	2304·	1·4864	·00180956	1·1675	48·796	6·9700	10·390	143·47	43·041	·096236	4·3637	229·17	·014350	69·848	·62607	2·8393	18
19	·040	1·0160	1600·	1·0323	·00125664	·81076	33·882	4·8403	7·2168	206·60	61·980	·13859	6·2837	159·14	·020616	48·506	1·3284	6·0250	19
20	·036	0·91439	1296·	[illegible]	·00101787	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	76·518	·17110	7·7577	128·90	[illegible]	39·280	1·9787	[illegible]	20

NOTES.

THE LAW COURTS.—During the vacation some alterations will be carried out in the electric light machine room at the Royal Courts of Justice.

NEW ZEALAND.—We notice that Sir Julius Vogel, well known in connection with electric lighting, is to be the new Colonial Treasurer and Postmaster-General of New Zealand.

TELEGRAPH REVENUE.—The total receipts from Postal Telegraphs between 1st April and 16th August were £675,000, against the same amount for a period of two days longer last year.

ELECTRIC LIGHT EXPERIMENTS.—The Royal Engineers at Cork have lately made some interesting experiments with torpedoes and the electric light at the entrance to Cork harbour.

EARTHQUAKE.—It is reported by telegram from Rome that a slight shock of earthquake was felt at Cosenza at 7 a.m. on the 19th inst. It was more severely felt at Rossano, but no damage was occasioned.

THUNDERSTORM IN PARIS.—A severe thunderstorm is reported to have occurred in Paris on Sunday night. Many houses were struck, but only one woman appears to have been injured by lightning, and that slightly.

EASTERN ELECTRIC LIGHT COMPANY.—The creditors of this company should send their names, &c., before the 15th December, to the liquidators, Messrs. Heywood, Bull, and Clark, at 19, Great Winchester-street, E.C.

DEATH OF MR. ARNOUX.—It is announced from New York that Mr. Anthony Arnoux, a pioneer of electric lighting business in that city, recently committed suicide. He was treasurer of the Arnoux-Hochhausen Electric Company.

THE NEW ATLANTIC CABLE.—The Waterville correspondent of the *Daily Chronicle* telegraphed on Saturday last :—"The 'Faraday' still proceeds satisfactorily with the second Bennett-Mackay cable. The weather is fine but cloudy. The alterations at Cable House are approaching completion."

"H" AT PARIS.—M. Mascart has found, using Gauss's method of calculation, that the mean value of the horizontal component of the earth's magnetism at the observatory of Parc Saint-Maur was, on the 1st July last, $H = \cdot 19414$ in C.-G.-S. units. The probable error was less than ·0001.

TELEGRAPHIC COMMUNICATION WITH GREECE.—According to a telegram from Vienna telegraphic communication between all the Greek islands and the mainland has just been completed, thus establishing direct communication by telegraph between the islands in question and all parts of Europe.

BUSINESS NOTICE.—Mr. Thomas H. Harrison, who for over twelve months has had charge of the Gülcher Electric Light Company's works at Battersea, and has carried out some of their largest installations, has been appointed agent to the company. His offices are at 5, Lawrence Pountney-lane, E.C.

DEATH OF AN ELECTRICIAN.—A French paper announces the death of M. B. Meyer, a well-known electrician and author of several works. M. Meyer invented a multiplex telegraph, which bears his name. He was a Chevalier of the Legion of Honour. For some years past he had lived in retirement at Malzéville, near Nancy, where he died.

AN ELECTRIC BRAKE.—A trial of the Walcker electric brake, which is in use in America, was recently made on the tramway between Turin and Piossasio. It is stated that by its means two cars running at a speed af 35km. per hour were stopped in six seconds, and within a distance of 18m. The brake is being shown at the Turin Exhibition.

THE BRITISH ASSOCIATION MEETING.—Most of those who are going to attend the forthcoming meeting in Montreal have sailed. Among the last to go were Professor Dewar, General and Lady Lefroy, Mr. W. H. Preece, Lord and Lady Rayleigh, Professor W. Chandler Roberts, and the Earl of Rosse, who left Liverpool on Saturday last in the Allan liner "Parisian."

UNIVERSITY COLLEGE, BRISTOL.—The next session will open on the 7th October. The department of experimental physics will be, as heretofore, under the direction of Professor Silvanus P. Thompson, D.Sc. There is a physical and electrical laboratory attached to the college, which is open daily and on Wednesday evenings. Details of the course can be had of the registrar.

ELECTRIC LIGHTING IN SOUTH KENSINGTON.—It appears that the revocation by the Board of Trade of the provisional order for lighting certain streets in South Kensington has been a source of much regret to many of the inhabitants of the district; but it is hoped that next year a feasible scheme for the lighting of the streets by means of electricity will be matured and carried into practical operation.

UNDERGROUND WIRES IN CHICAGO.—The city of Chicago has brought five suits against the Baltimore and Ohio and Western Union Telegraph Companies, for contravening the bye laws by maintaining three overhead wires. It will be remembered that the city authorities some time since ordered all wires to be laid underground, under heavy penalties for disobedience. It is understood that the above will be test cases.

ELECTRIC RAILWAYS.—American electricians are just now taking up the question of electric railways with characteristic energy. The papers are full of projects for such railways here, there, and everywhere. New York is promised both underground and overhead railways, the cars on which are to be propelled by the aid of the electric current. Brush, Edison, Daft, Field, Hazard, and many others are engaged on experimental lines.

AN ATTEMPT TO REACH GENERAL GORDON.—It seems as if a man of poles and wire will reach General Gordon before any one else. A telegram has recently been received in London from Mr. E. Floyer, Inspector-General of Egyptian Telegraphs, and, by the way, an Englishman, dated from Debbas, stating that all was well, that he was six days only from Gordon, and endeavouring to pass on. We hope Mr. Floyer may succeed in accomplishing his task in safety.

THE ROYAL ENGINEERS.—Orders were received at Aldershot on Saturday for a portion of the 1st Division Telegraph Battalion, Royal Engineers, under the command of Captain Bennett and Lieutenant Tower, to at once hold themselves in readiness to embark for Egypt, to take part in the expedition up the Nile. They will take with them no less than a hundred miles of air line and about twenty-five miles of cable. These will be packed in parcels of about one hundred pounds each, so as to be easily carried by the men.

THUNDERSTORM IN ITALY.—A telegram from Rome, dated August 20, says :—"Last night a violent tempest broke over the region extending from Leghorn to Rome, including both cities. Rain and hail fell in great quantities; and the flashes of lightning, followed by deafening peals of thunder, were incessant. At Leghorn the cathedral was struck and set on fire, but the

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flames were quickly got under. Here the electric motor at the railway station was struck, and the lightning also fell at the cemetery of San Lorenzo and near the Basilica of St. Paul *extra muros*."

News from Egypt.—The Government have given orders for the telegraph line to be carried from Wady Halfa to Surras. It appears that some coils of telegraph wire lying on the deck of a steamer which recently attempted the passage of the first cataract on the Nile were instrumental in saving it from destruction. Owing to the mismanagement of the Arabs engaged to haul her over both hawsers broke, the anchors proved of no use to stop her, and she was only brought to by throwing overboard some coils of telegraph wire, which caught in the rocks and fortunately held her.

Globe Lightning.—M. Gaston Planté has been making some very interesting and instructive researches into the probable cause of globe lightning, as it is called. With the aid of secondary batteries he obtained a current having an E.M.F. as high as 4,000 volts, and by this means he very successfully imitated globe lightning on a small scale. The results of his experiments were communicated a few days since to the French Academy of Sciences, and we had hoped to have given them in this week's issue, together with illustrations, but are compelled to postpone the article until next week.

Appointment.—Mr. W. C. Martin, of Dundee, has been appointed manager of the Electromotive Force Company (Limited), electrical engineers, Glasgow. Mr. Martin has long been connected with the telephone and electric light companies in Scotland, he having assisted in establishing the first telephone exchanges in Dundee, Aberdeen, and Edinburgh; and his late services with the Brush Electric Light Company of Scotland will have widened his connection throughout all the principal towns in Scotland. The electric lighting business recently started by him in Dundee will now be carried out by the company.

Electric Lighting in Brussels.—The Grand Place at Brussels is to be lighted by arc lamps. The machinery will be placed in a cellar in the Maison du Roi, and the current conducted thence to the lamps by underground cables. Two dynamos will be used at first, driven by a 12 horse-power Otto gas engine. The installation is being made by the Compagnie Générale d'Electricité, under the superintendence of M. Wybauw, the city engineer. Jaspar lamps will be used, and it is rumoured that the Hotel de Ville is to be lighted by incandescent lamps, the current being supplied from the same dynamo room.

The Philadelphia Exhibition.—The following gentlemen have been selected as members of the electrical commission to conduct experiments on the occasion of the exhibition at the Franklin Institute:—Professor H. A. Rowland, Baltimore; Professor John Trowbridge, Cambridge; Professor G. F. Barker, Philadelphia; Professor R. A. Fisk, San Francisco; Professor M. B. Snyder, Philadelphia; Professor J. Willard Gibbs, New Haven; Professor Simon Newcomb, Washington; Professor E. J. Houston, Philadelphia; Professor C. A. Young, Princeton; and Dr. W. H. Wahl, Philadelphia. Professor Rowland is chairman.

Electric Railway at Cleveland, U.S.—Later details of the application of electricity to the propulsion of tramcars on the East Cleveland-street Railroad Company's line at Cleveland, U.S., have come to hand, though they are not very explicit or satisfactory. Thus we learn that a car was propelled, "at first slowly, at length at a speed of probably five miles an hour, though the inventors (Messrs. Knight, Bentley, and Brush) claim that from eight to fifteen miles an hour can be obtained." We note, however, that the track on which the experiment was made "is probably the roughest to be found in the city of Cleveland."

Electric Lighting for Lighthouses.—The Trinity yacht "Argus" has been engaged during the week with the Trinity House authorities and a party of scientific gentlemen from Canada in making a series of very important observations from the Channel in connection with the experimental lighthouses at the South Foreland, and the full extent of the penetrating power of the lights is being tested under various conditions. Captain Sidney Webb, Master of Trinity House, and Mr. Price Edwards are conducting the observations, which are expected to last several weeks. An interesting article on this subject, which we reprint from *Nature*, will be found in another column.

The Prince of Wales's Visit to Newcastle.—Great preparations were made in Newcastle-on-Tyne for the visit of the Prince and Princess of Wales. Both gas and electricity contributed to the illuminations, which were carried out on a large scale. It was intended to have an arc lamp on the upper lantern of St. Nicholas Church, which would be visible for many miles round. Their Royal Highnesses stayed with Sir William Armstrong, at Cragside, Rothbury, which it will be remembered has for some time past been lighted by incandescent lamps. A large arc lamp was placed at the top of the house for the occasion, and was used to light up the surrounding country.

Electric Lighting in Church.—The Roman Catholic church of St. John, built by the Marquis of Bute, at Old Cumnock, Ayrshire, has recently been fitted throughout with the electric light, under the personal superintendence of Mr. William Massey, electrical engineer, of Twyford. There are in all about 70 incandescent lamps of 20 candle-power, and the effect is very good, the architectural features of the building having been carefully studied and the lamps arranged with due regard to the religious character of the place. The necessary current is supplied by means of a dynamo and steam engine placed in a small house hidden among the trees of the churchyard, where it is also intended to generate electricity for working the organ bellows.

The Greely Expedition.—According to telegrams from New York, Lieutenant Greely has published further details of his three years' enforced residence in the Arctic regions. During that time he made some observations which will no doubt prove useful to scientific men. He says "the extremes of temperature at the camp on Discovery Bay, which they had named Fort Conger, was from 52 deg. above freezing point to 66 below. In February, 1883, the mercury was frozen into a solid mass, and continued in that state for 15 days. The ordinary outdoor clothing of heavy flannels was found to be quite sufficient even on the coldest days. The extreme range of the barometer was from 29in. to 31in. The electrometer registered nothing. The aurora was noiseless, which is contrary to Sir George Nares's experience in 1876, but it was sufficiently bright to cast a shadow."

Lighthouses in France.—According to a recent communication published in the *Bulletin* of the Societé Internationale des Electriciens, the electric lamps in use in French lighthouses have proved far more satisfactory than the oil lamps. It is further found that the former cost for maintenance from four to six times less than gas or oil per unit of light emitted. Magneto electric machines which supply alternate currents are used together with Serrin arc lamps. The latter have been modified by M. Berjot to suit the particular

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service for which they are required, and quite recently M. Berjot's lamp has been improved by M. Le Baron. Berjot's modification consisted in substituting for the iron core of the electro-magnet in Serrin's lamp, which became so heated by the alternate currents as to cause a dilation of the parts of the regulator, and consequently interfered with its proper working, four solenoids placed in a shunt from the main circuit.

Electricity and Colliery Explosions.—Mr. Edward Thompson, C.E., writes to the *Daily Chronicle* on this subject as follows:—"It is well known that when the atmosphere becomes too highly charged, the electric fluid passes from the clouds to the earth in the form of lightning, to distribute itself in the ground. But to what depth does it enter, and to what degree does it become distributed? Is it that it passes from one stratum to another, until certain strata become charged to the same extent as the clouds from which it originally came? If this be the case, is it not probable that a sudden fall in the temperature of the air may cause the electric fluid to again return to the atmosphere, or be drawn off by the cool air? But what has this to do with colliery explosions? The theory is this: the mine has been supplied for months with air charged with electricity, which in its passage has left behind a large amount in the coal strata. A sudden change in the temperature and composition of the atmosphere takes place; the cool air is forced into the mine, then a peal of thunder is heard beneath the ground, and the electric fluid finds a ready passage up the shaft to again distribute itself in the clouds. If this theory be correct, at the fall of the year we may expect to hear of several colliery explosions."

Printing by Electricity.—The *Lawrence American* of July 9th says:—"For more than ten days past the entire power for running not only the large Hoe press upon which this paper is printed, but for the cylinder and job presses of the entire printing establishment, has been from electricity coming over a single wire from the dynamos, four blocks away; the fires under our steam boiler have now slept nearly two weeks, while the little electrical machine, weighing only 800lb., quietly, steadily, unceasingly, without jarring or difficulty, keeps up its marvellously equal revolutions. There is no delay in waiting to get up steam, no loss of time from any of the ordinary uncertainty of boilers, but whenever the minute comes when the power is required, a single movement of the lever, and the wheel starts upon its swift unchanging revolutions. We believe the *American* is the first daily newspaper, if not the first regularly published journal of any description, to be printed in this country with electrical power. To what will not this yet but little understood power be turned?" It may be the first daily newspaper printed by this agency, but it is not the first journal so printed by many years. On January 18th, 1840, the *Electro-Magnet and Mechanic's Intelligencer* appeared in New York; it was printed by a press worked by an electro-magnetic machine made and invented by Mr. Devenport, an ingenious and go-a-head blacksmith of Philadelphia. A reference to his machine will be found at p. 399 of our 9th volume.

Another Electric Launch.—On Monday a trial of an electric launch was made on the canal from Bolton to Bury by Mr. Banks, electrician, 32, Corporation-street, Bolton. The launch is 21ft. by 4ft. 6in. beam, and has been built specially for this purpose. The current is supplied by twenty F.-S.-V. accumulators (½ h.-p. type), and actuates a Rekenzaun motor coupled to the propeller shaft direct. The E.M.F. during the trip varied from 45 to 35 volts, and the rate of discharge was 31 amperes. The propeller is 12in. diameter and 11in. pitch, and makes 450 revolutions per minute. This is being replaced with another only 7in. pitch, when it is expected that the maximum speed obtained on Monday will be increased from six to eight miles per hour. Great satisfaction was expressed at the performance of the little craft by J. R. Budson, Esq. (for whom the launch has been built) and party, the only drawback being the weeds, &c., in the canal getting entangled in the propeller. To persons on the banks of the canal it appeared somewhat strange, and various suggestions were made as to the cause of motion, as nothing can be seen standing above the sides of the boat. The departure and arrival of the boat was witnessed by a large number of people, including many gentlemen interested in the progress of electricity. The cells and motor were working for over three hours, and with the exception of a slight heating of the motor everything was satisfactory. The accumulators were charged at Mr. Banks's works in Lorne-street, and so far have given every satisfaction. The boat weighs 7cwt., cells (charged) 7cwt., and the motor 1cwt. A switch is placed convenient for the man in charge of the rudder, whereby he is enabled to have any number of cells at work. The motor is also fitted with reversing gear.

Balloons.—Particulars of the balloon experiments recently carried out by Captain Rénard, at Meudon, mention of which was made in our last issue, are beginning to leak out. The *Standard's* Paris correspondent says that on Tuesday "the voyage was described in detail at the Academy of Sciences. It took place on the 9th inst. The weather was calm. The balloon, of elliptical form, was fitted with an electric motor, a screw, and a rudder. It rose to a height of fifty metres. Captain Krebs handled the rudder, and Captain Rénard maintained the permanence of elevation. When the screw had acquired a rotary movement the balloon moved towards the point fixed upon, which was the Villebon Hermitage. At this moment there was a breeze from the east of the celerity of five metres a second, and the balloon sailed against the wind. On reaching the Villebon Hermitage the officer in charge of the rudder waved a flag, which was the signal of return. The balloon was then seen to tack, describing in so doing a semi-circle of three hundred metres radius, and sailed towards Meudon. On approaching the lawn from which the ascent had been made the balloon gradually descended in an oblique direction, and reached the spot aimed at. It is intended that further experiments shall be made in which a committee of the Academy are to take part. The Minister of War has been furnished with full details of the apparatus, but these are, of course, kept a close secret from the public. The motor is said to be composed (*sic*) of a series of accumulators supplying for some hours a power of ten horses. These accumulators set in motion the screw by which the apparatus is propelled. The balloon is of light silk, of a very resisting quality, and covered with a netting which bears the car and the propeller." We presume the *Standard's* correspondent means to say that these accumulators set in motion a motor which actuates a screw by which the apparatus is propelled.

The Post Office Protection Act.—This Bill, which was passed during the Session just concluded, is to come into force on the 1st September. Amongst other things it enacts that "every person who forges or wilfully and without due authority alters a telegram, knowing the same to be forged or wilfully and without due authority altered, and who transmits by telegraph as a telegram, or utters as a telegram, any message or communication which he knows to be not a telegram, shall, whether he had or had not an intent to defraud, be guilty of a misdemeanour, and shall be liable on summary conviction to a fine not exceeding £10, and on conviction on indictment to imprisonment with or without hard

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labour for a period not exceeding twelve months. If any person, being in the employment of a telegraph company (that is, any company, corporation, or persons carrying on the business of sending telegrams for the public under whatever authority, or in whatever manner such company, corporation, or persons may act or be constituted), wilfully omits or delays to transmit or deliver any telegram, or by any wilful act or omission prevents or delays the transmission or delivery of any telegram, or improperly divulges to any person the purport of any telegram, such person shall be guilty of a misdemeanour, and be liable on summary conviction to a fine not exceeding £20 sterling, and on conviction on indictment to imprisonment with or without hard labour for a term not exceeding one year, alternatively to a fine of £200. If any person, being in the employment of a telegraph company, as already defined, negligently omits or delays to transmit or deliver any telegram, or by any negligent act or omission prevents or delays the delivery or transmission of any telegram, such person shall be liable on summary conviction to a fine not exceeding £20 sterling. Nothing in this Act shall extend to any act or omission on the part of a person employed by a telegraph company in relation to the transmission or delivery of a telegram where such act or omission is in accordance with the provisions of any international telegraph convention for the time being in force in the United Kingdom, or with any reasonable regulations with respect to the transmission and delivery of telegrams made by the telegraph company and approved by the Postmaster-General."

THE DAFT ELECTRIC RAILWAY.—The *Electrician* of New York says:—"The new railway at Coney Island is operated by the Daft system, and extends for 780ft. along the west side of the West Brighton Pier. The track is of 2ft. gauge, the rails being of the T pattern, 20ft. in length, 8lbs. to the foot. These are laid on strips of wood, and all firmly bolted to the pier planking. No attempt is made at insulation, none being needed, as on the wettest days the escape of current would be scarcely perceptible. The dynamo is shunt wound, and capable of furnishing a 6 horse-power current. Like all of Professor Daft's machines, the E.M.F. is extremely low. The intensity of the current varies with the external resistance, and upon this depends the speed of the generator. Its weight is about 650lbs. and its normal speed 1,100. It is driven by an 8 horse-power vertical engine, with boiler to correspond, manufactured by the New York Safety Steam Power Company. The speed of the engine being 250, direct belting was possible. The motor is of the same model as its predecessor, the Ampère, which made the successful trial test at Saratoga. Its name, Pacinotti, is equally appropriate. The body is built of 2in. ash, and is 6½ft. long by 3ft. wide. The superstructure is simply a dash-board 20in. high, to which the switches for controlling the motor are attached; a box on the rear, within which is placed the receiving dynamo. In front of this box and attached to it is the driver's seat. Upon his right is the lever for reversing the brushes on the commutator, and, consequently, the direction of its rotation. The running gear consists of four 12in. wheels with 4in. centres. To prevent short circuiting between the rails, the wheels on one side are insulated by the use of wooden centres. A wooden apron on the four sides, extending to within an inch of the rails, conceals the lower part of the motor. The motion is transmitted from the receiver in the box to a counter shaft beneath, and from there to each pair of wheels. The receiver is compound, having a capacity of from 3 to 4 horse-power. Numerous variations in its resistance may be made, thus controlling the speed of the motor. Its weight is about 450lbs., and the speed of the armature from which the best results are obtained, about 1,400. The speed is of course under control of the driver through his switches. The right-hand switch combines in an ingenious manner a make and break switch, with one for regulating the flow of the current to the receiver. The destructive results to an ordinary switch by the breaking of a heavy current have been avoided in this contrivance, as also in the brake switch, without the introduction of useless resistance. Although in use for some time they evince but the faintest traces of fusion. Two cars are provided for the transportation of passengers, each 12ft. 2in. long and 32in. wide, weighing about 400lb., and accommodating 20 persons, 10 on each side sitting back to back, making a normal load of 40. As many as 50 people have been carried at one time, a total weight of about 4 tons. The weight of the Pacinotti is about 1,200lb., and its maximum speed from 12 to 15 miles per hour, although this is obviously limited on so short a track."

ELECTRIC LIGHT PATENTS IN AMERICA.—With regard to the decision of Judge Shipman in the suit brought against the United States Company by the Brush Company, reported in our issue of the 2nd instant, p. 283, the Brush Company of Cleveland, U.S., have issued the following circular:—"It will, no doubt, surprise our agencies and lighting companies to learn that a suit of this company against the United States Electric Lighting Company, which has been before the court for a long time past, has been decided by Judge Shipman in favour of the defendants. In 1876, two years prior to the date of Mr. Brush's patent, a man named Hayes made a lamp containing a clamp somewhat resembling the clamp used in the Brush lamp, but used quite differently. The lamp was a failure, and after a number of attempts to make it work properly, the clamp was taken off, thrown into a scrap box, and the whole matter dropped. No other lamp was ever made with the clamp, and as this one had never been regarded as successful, either by the maker or any one else, until it was thought that it could be made use of to beat us, and was, as we believed, purely experimental, we treated it as an abandoned experiment, and therefore no anticipation of Mr. Brush's invention, which was entirely successful from the start. Judge Shipman decided, but apparently after serious doubt, that it was not strictly an abandoned experiment, and on this point alone decided the case against us. The case will be at once appealed to the United States Supreme Court, and followed up to the end. The only issue involved in the final hearing of this suit was the lifting and feeding clamp in the lamp. We have other suits still pending against the agents of the United States Company, or users of its apparatus, on other patents that are of much more importance than the one recently decided. We also have a number of other suits on various patents against other systems of lighting, as will be seen by the accompanying list, and infringers will do well to bear in mind that so far only a single one out of more than forty Brush patents has been judicially declared invalid, and we propose, as heretofore, to prosecute all infringers who disregard our rights. Suits are now in progress in various United States circuit courts against users of infringing apparatus covered by patents other than the one passed on by Judge Shipman. Among these are suits against users of the following systems:—The United States (Weston), the Fuller Electrical Company, the Excelsior Electric Light Company (Arnoux and Hochhausen), the Schuyler Company, the Van Depoele Company, the Boulton Carbon Company, the Pittsburgh Carbon Company. Suits are also in preparation against other infringers, including the Thomson-Houston system, which infringes some of our most important patents upon the

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dynamo machine. The above suits include many different patents, all of which are controlled by us."

Electric Lighting.—An answer to the letter of "A. S.," which appeared in *The Times* of the 7th inst., and which we reprinted in our issue of the 9th inst., appeared in last Wednesday's issue of that journal over the signature "G." The writer says:—"I think the public generally will agree with him ('A. S.') in thinking that the experimental installations, both in public and private establishments, prove the excellence of the electric light and its immense advantage over gas. In reply to the question so commonly asked, 'Why does not electric lighting go ahead?' 'A. S.' furnishes an answer which practically throws the whole blame upon the Electric Lighting Act of 1882, and that because, under this Act, it is provided that only a 19 years' contract may be entered into. It does not seem to have been sound policy to limit the contracts to nineteen years, and it is probable that this limit has checked the application of electricity for lighting our streets and houses; but I think it will be found that fault lies also with the electric lighting companies. For instance, the Act provides, and very reasonably in the interest of the public, that undertakers shall not prescribe to householders and others to whom they supply current the use of any particular kind or form of lamp. This practically means that the undertakers shall supply to consumers an electrical current of varying properties, so that any kind of lamp may be used. I would ask, which of the electrical companies, or under what, if any, system this condition can be complied with? That it must be complied with before electricity can be generally applied is evident, whether the Act requires it or not. Then, again, is it possible to do more than establish isolated installations, when, in order to light any quantity of incandescent, or, as they are now called, glow lamps, it is necessary to have noisy machinery on or near the premises lighted, the cost of bringing a suitable current from a distance being prohibitive on account of the expense of the leads? Hence it follows that to enable the public generally to profit by the electric light the current must be brought from convenient stations at a distance (in some cases considerable) from the area of consumption. Again, I ask, what electric lighting company or system can do this economically? 'A.S.' speaks of accumulators as affording the means of storing electricity from the street wires for distribution in the houses; but accumulators involve a serious and unavoidable loss, and, though probably valuable if not indispensable as a reserve, can hardly furnish a solution of the problem. Although the unhealthy gambling of which electric lighting, as an honest industry, was the victim some 18 months ago, has retarded its legitimate development, now that the atmosphere has been cleared by the disappearance of many bogus and other unsound companies, it is hoped that the remaining companies will seriously apply themselves to the task, difficult, perhaps, but by no means impossible, of supplying electricity economically in the various forms required by different consumers; and if this result were really attained there can be little doubt that an appreciative public would gratefully accept the boon. There is no reason either to suppose that the enormous gas interests would suffer by a development of electrical enterprise; on the contrary, it would probably be found that, although less gas would be used for producing light, more would be employed for heating purposes, for which latter a less expensive manufacture would suffice. I think the exercise of a little public spirit, which would be found the soundest policy for private interests, too, leading to the united action of the principal companies interested, would bring about the happiest results for consumers and shareholders alike, both as regards gas and electricity."

What Will be Heard at Montreal?—*The Times* of the 19th inst. indulges in a little prophesy as to what will be heard at Montreal when the British Association meeting has been opened. The President of the Association, Lord Rayleigh, is, says the prophet, both a man of affairs, a Cambridge professor, and an original worker in some of the most abstruse departments of physics. He will be able, in his address, to refer to what he saw of Canada in his visit of 17 years ago, and is likely enough to gratify his audience by the admiring terms in which he will be able to speak of the past of the Dominion and the strong hopes which he has formed of its future. But Lord Rayleigh has too high an estimate of his responsibilities and position as president to occupy his hour in saying pleasant things of the Canadians. The branch of science with which he is more particularly connected has the widest and most varied field and the most far-reaching bearings in practice; and, therefore, an account of recent progress in the various departments of physical science, when given with Lord Rayleigh's well-known skill and clearness, would be sure to interest any intelligent audience. Such, therefore, we believe, is likely to be the subject of this year's presidential address. Lord Rayleigh cannot but refer to the serious loss which science has sustained since last meeting in the death of Sir William Siemens, and he may take advantage of the opportunity to say a good word on behalf of inventors. Electricity, especially in some of its practical applications, cannot fail to come under the notice of the president, and he may have some hopeful words to say on the future of electric lighting. Among the names he may have to mention of those who have done important service in the recent progress of electricity as well as other branches of physics, will probably be some whom the United States, at least, if not Canada, can claim as citizens. Of almost equal practical importance with electricity is thermodynamics, including as it does such curious problems as the dissipation of energy, and such inventions as the steam engine. Under the heads of motion of fluids, acoustics, and optics Lord Rayleigh may also have to record important advances in recent years, and in these connections he cannot but refer to his eminent predecessor at Cambridge, the late Clerk-Maxwell. It is possible also that the president may make some reference to the place of science in education, and if so his opinions are not likely to be very acceptable to the out-and-out adherents of the older leaning. It would be only in accordance with precedent that the relations of science to the intangible and the unseen should be touched upon in the presidential address; but if Lord Rayleigh does so we may be sure it will be in words of tenderness and hope. Such, so far as we can learn, are likely to be some of the topics touched on in the presidential address at Montreal; of one thing we may feel sure that in Lord Rayleigh's hands it will be worthy both of the Association and of the unprecedented occasion. From the presidents of sections we expect, of course, to have something more special than from the President of the Association. Sir William Thomson, as president of the physical section, will no doubt choose some special point in his wide domain for the subject of his discourse; but we may be sure that he will not let the opportunity pass without throwing out some ideas bearing on the very foundations of scientific knowledge. If rumour speaks correctly Sir William Thomson is likely to deal briefly with a subject bearing closely on the nature of matter itself, and some of the ideas he is likely to broach will probably prove suggestive of new lines of experiment as well as of speculation. Indeed, his address may turn out to be one of those flashes of speculative genius which occasionally burst forth and lighten up the dark places of science.

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THE INDUCTION OF CURRENTS IN CORES.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 201.)

Normal or Harmonic Distributions of Magnetic Force.

The problem of determining the manner in which the magnetic force and induced current in a core inserted within a long solenoidal coil vary, when the coil circuit containing a battery or other source of steady E.M.F. is suddenly closed, is somewhat more simply managed by reversing it, and finding the manner in which the magnetic force subsides when the E.M.F., after having set up the permanent state, is suddenly removed, without interrupting the circuit or altering its resistance. And this is a special case of the more general, but theoretically quite as easily managed, problem of starting at a given moment with *any* distribution of magnetic force in the core, subject only to the condition of being directed parallel to the axis, and only varying in strength with distance from the axis, and, leaving the system to itself, determining the subsequent state of things, the coil circuit being open or closed, but without other E.M.F. than that arising from the subsidence of the core's induction. The initial strength of magnetic force may vary from layer to layer in a perfectly arbitrary manner, either continuously or with abrupt changes of strength.

As regards the arbitrariness, we may obviously, by means of a previously acting arbitrarily variable E.M.F. in the coil circuit, set up an infinite number of different states of magnetic force. But they will not be arbitrary, because the magnetic force will, in all such cases, vary continuously in strength from layer to layer. That abrupt changes of strength are admissible in the initial state may be thus shown. Considering the core as made up of a great though finite number of thin concentric tubular shells, we have a set of linear electric circuits. From their coefficients of self and mutual induction, and their resistances, we have all the data required for determining what will happen when we start with given currents in these circuits, and leave the system to itself. The circuits being independent, the initial strengths of current in them may have any values we please; and since there is no breach of continuity in passing from a finite number of circuits to an infinite number making up a solid core, it follows that in the mathematical treatment of the subject the initial current, and therefore also the magnetic force, may vary abruptly in passing from the axis outward, although of course special means would be required to set up the discontinuities in strength.

We may also, from the theory of linear circuits, see at once what the form of our solutions must be in the case of a continuous core. For, if there are n circuits, there are n distinct rates of subsidence, and the currents at time t after the moment of leaving the system to itself are given by n equations of n terms each, of the form,

$$\left.\begin{aligned}\gamma_1 &= A_1e^{D_1t} + A_2e^{D_2t} + A_3e^{D_3t} + \dots\\ \gamma_2 &= B_1e^{D_1t} + B_2e^{D_2t} + B_3e^{D_3t} + \dots\\ \gamma_3 &= C_1e^{D_1t} + C_2e^{D_2t} + C_3e^{D_3t} + \dots\\ &\dots\dots\dots\dots\end{aligned}\right\} \quad . \quad . \quad . \quad (64)$$

$\gamma_1, \gamma_2, \dots$ being the currents at the time t in the first, second, &c., circuits. Here there are n constants $D_1, D_2, \dots$ which are the same for every current, and n^2 constants A, B, C, . . . but the *ratios* of the constants in any column are fixed by the electrical data (as are also D_1, D_2, &c.), leaving only one constant in each column arbitrary, making n altogether, whose values may be found from the given initial strengths of the n currents, thus completing the solution.

Now, these circuits being concentric shells to start with, in passing to the case of a continuous core, making the number of shells infinite, we see first that the form of the solution must remain unaltered. Next, that the number of constants D_1, D_2, &c., becomes infinite, whilst they are the same for all parts of the core. Thirdly, that, supposing $\gamma_1, \gamma_2, \dots$ are the currents in consecutive shells passing from the axis outward, the coefficients A, B, C, . . . in any one column of (64) become the successive values of a continuous function of r, whose magnitude alone is left arbitrary, so that we may write (66) in the form of a single equation

$$\gamma = A_1u_1e^{D_1t} + A_2u_2e^{D_2t} + A_3u_3e^{D_3t} + \dots \quad . \quad . \quad . \quad . \quad (65)$$

γ signifying the current at distance r from the axis, $u_1, u_2 \dots$ being functions of r determined solely by the electrical data, and $A_1\ A_2 \dots$ constants to settle the absolute magnitude of each term.

And lastly, we see that, since at the time $t=0$, we have

$$\gamma_0 = A_1u_1 + A_2u_2 + A_3u_3 + \dots,$$

and since the initial current γ_0 is arbitrary, it must be possible to expand any function of r in a series of u's, by properly determining the magnitude of the A's.

Special proofs of the possibility of the expansion of any function in series of a definite kind are usually of a singularly obscure and unsatisfactory nature, quite apart from their speciality or want of applicability to other forms of series. But if, as in the above, we pass from the solution of a set of linear differential equations with one variable, the time, to that of a partial differential equation, we see the absolute necessity of the possibility of the expansion. It would be a miracle were the expansion impossible. Have we got the right *form* of function in the first place, and next, have we got *all* of them, to satisfy the conditions of a physical problem? If so, the possibility of the expansion requires no proof.

By (65), and the relation $\gamma = -\frac{1}{4\pi}\frac{dH}{dr}$ between the current and magnetic force, the general solution for the magnetic force is of the same form, viz.:

$$H = A_1u_1e^{D_1t} + A_2u_2e^{D_2t} + \dots \quad . \quad . \quad . \quad . \quad (66)$$

where u_1, u_2, &c., are functions of r to be found by putting the elementary solution ue^{Dt} for H in the characteristic equation of H, viz.:—

$$\frac{1}{r}\frac{d}{dr}r\frac{dH}{dr} = \frac{4\pi\mu}{\rho}\frac{dH}{dt} \quad . \quad . \quad . \quad (14)\ bis$$

Since $\frac{d}{dt}e^{Dt} = De^{Dt}$, we obtain

$$\frac{1}{r}\frac{d}{dr}r\frac{du}{dr} = \frac{4\pi\mu}{\rho}Du \quad . \quad . \quad . \quad . \quad (67)$$

whose solution gives the function u. Being of the second order, it has two distinct solutions, say v and w, so that

$$u = av + bw \quad . \quad . \quad . \quad . \quad . \quad . \quad (68)$$

is the complete solution. One of v and w may be found at once by assuming $u = a_0 + a_1r + a_2r^2 + \dots$, inserting in (67), and making it true for every power of r. This gives

$$v = 1 + \frac{4\pi\mu}{\rho}\frac{r^2D}{2^2} + \left(\frac{4\pi\mu}{\rho}\right)^2\frac{r^4D^2}{2^24^2} + \left(\frac{4\pi\mu}{\rho}\right)^3\frac{r^6D^3}{2^24^26^2} + \dots \quad . \quad (69)$$

Put $\frac{4\pi\mu D}{\rho} = -n^2$, for subsequent convenience, and we hav

$$v = 1 - \frac{n^2r^2}{2^2} + \frac{n^4r^4}{2^24^2} - \frac{n^6r^6}{2^24^26^2} + \dots = J_0(nr) \quad . \quad (70)$$

for one solution of (67). This function is usually denoted by $J_0(nr)$, and was first employed by Fourier. Whether he invented it or discovered it is a doubtful point; the question is raised whether mathematical truths lie within the human mind alone, or whether the infinite body of known and unknown mathematics could exist in a dead universe. But this is metaphysics, which is all vanity and vexation of spirit, especially in this shirt-sleeve weather.

The other solution may be shown to be

$$w = \frac{2}{\pi}\left\{ v\log nr + \frac{n^2r^2}{2^2} - (1+\tfrac{1}{2})\frac{n^4r^4}{2^24^2} + (1+\tfrac{1}{2}+\tfrac{1}{3})\frac{n^6r^6}{2^24^26^2} - \dots\right\} \quad (71)$$

For proof it is sufficient to test that it satisfies (67) and is not the same as (70).

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The general form of the *u*'s in (66) is thus completely known. But we do not want the second solution, *w*, at all at present in dealing with a core solid to its centre, because *w* becomes infinite when $r=0$, on account of the logarithm. Its coefficients, therefore, require to be zero to make the magnetic force finite at the axis of core, *i.e.*, *w* does not come in at all. It will occur later. At present we have

$$H = A_1 v_1 e^{D_1 t} + A_2 v_2 e^{D_2 t} + \dots \quad . \quad . \quad . \quad (72)$$

in which the *v*'s only differ from one another in having a different value of *n* or D.

The nature of the function *v* is shown in Fig. 1. Distance from the axis of the core is measured along the base line to the right, and the value of *v* upward. The curve *v* crosses the base line an infinite number of times. After a few fluctuations it becomes very nearly a sinusoidal curve, but with diminishing amplitude, varying inversely as the square root of the distance from the axis.

The magnetic interpretation is, if the strength of magnetic force in a core at different distances from its axis be represented by the curve *v* the magnetic force will subside everywhere at the same rate. When it has fallen to $1/m$ of its initial strength at any point, it has fallen to $1/m$ of its strength at every other point, so that the curve representing the force at any moment remains similar to itself.

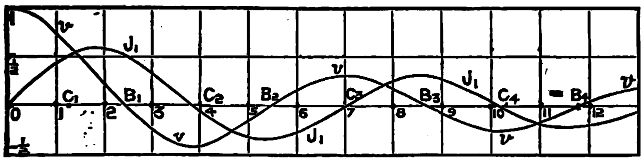

Fig. 1.

The other curve in Fig. 1, marked J_1, shows in a similar manner the strength of the current accompanying the magnetic force; its equation is

$$J_1(nr) = -\frac{d}{d(nr)} J_0(nr) \quad . \quad . \quad . \quad . \quad .(73)$$

or, by (70),

$$J_1(nr) = \frac{nr}{2}\left(1 - \tfrac{1}{2}\frac{n^2r^2}{2^2} + \tfrac{1}{3}\frac{n^4r^4}{2^24^2} - \dots\right) \quad . \quad . \quad (74)$$

The curve *v* may be drawn to any vertical scale, since this amounts merely to fixing the absolute strength of magnetic force. But as to the horizontal scale, this depends upon what the boundary conditions are. By means of a suitable boundary condition we may arrange to have the boundary at any distance along the base in Fig. 1, where of course the curve must stop.

Example I.—Coil Circuit Interrupted.

If the coil be absent, or its circuit broken, the boundary value of the magnetic force is compelled to be zero. Now in Fig. 1, $v=0$ at B_1, B_2, &c., and at any of these places we may imagine the core to terminate and the curve stop. This gives a definite series of values to *n*, of which the first four are

$$\left.\begin{array}{llll} an_1 = 2{\cdot}405, & an_2 = 5{\cdot}520, & an_3 = 8{\cdot}654, & an_4 = 11{\cdot}791; \\ a^2n_1^2 = 5{\cdot}783, & a^2n_2^2 = 30{\cdot}471, & a^2n_3^2 = 74{\cdot}888, & a^2n_4^2 = 139{\cdot}037. \end{array}\right\} \quad (75)$$

Now, in Fig. 2, the base line, OP, represents *a*, the radius of the core, and the four curves, the first four normal distributions of magnetic force, being the curve *v* in Fig. 1, drawn upon four different horizontal scales, so as to reach the boundary, P, at the first, second, third, and fourth roots of $v=0$. There are an infinite number of other normal systems, corresponding to the higher roots. The normal system v_m divides the core into a solid central cylinder, surrounded by $m-1$ concentric tubes, at whose boundaries the magnetic force vanishes, being oppositely directed in consecutive tubes. The corresponding current vanishes at the places of maximum magnetic force, and the magnetic force vanishes at about the middle of each current segment.

The time constant measuring the slowness of subsidence of a normal system is

$$-1/D = 4\pi\mu/\rho n^2,$$

thus being proportional to the magnetic permeability, to the conductivity, to the sectional area of the core, and inversely to the square of *na*. Of all metals except iron, copper is the one in which any normal system subsides most slowly; on the other hand, the great permeability of soft iron overbalances its comparatively low conductivity and makes it the metal of slowest subsidence.

Copper.—$\rho = 1{,}700$, $\mu = 1$. These make $4\pi\mu/\rho = {\cdot}0074$, and the time constants of the first four normal systems to be, by (75),

${\cdot}0013a^2$, ${\cdot}00024a^2$, ${\cdot}000099a^2$, $000054a^2$, seconds,

where *a* is the radius of the core in centimetres.

Iron.—$\rho = 10{,}000$, $\mu = 100$ say. These make $4\pi\mu/\rho = {\cdot}1256$, and the time constants

${\cdot}0217a^2$, ${\cdot}0041a^2$, ${\cdot}0017a^2$, ${\cdot}0009a^2$,

which are 17 times as large as for a copper core of the same radius. In an iron core of 10 cm. radius (5in. diameter), the time taken by the first and most important normal system of magnetic force, inducing a current only in the core itself, to fall in strength from 2·718 to 1 would be 2·17 seconds. If of 1 m. radius it would take 217 seconds.

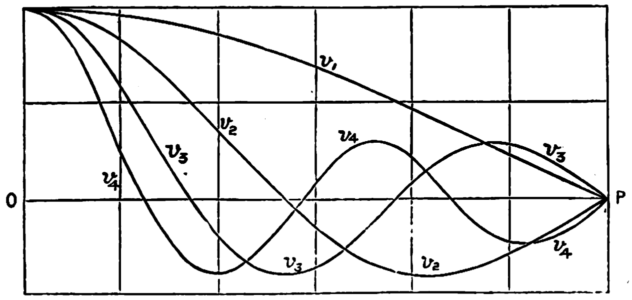

Fig. 2.

Note on Earth Currents.

The remarkable slowness of subsidence of currents in large masses of metal, or, equivalently, in proportionately larger masses of badly conducting material, is vaguely suggestive in regard to earth currents. Without intending any strict comparison, it may be remarked, first, that although the "earth' may be poorly conducting, yet there is a good deal of it. And next, that the "earth currents" observed on long lines of telegraph during magnetic storms are, neglecting the minor fluctuations, remarkably alike in their behaviour in some respects. Although a big "wave" may set in one way, and continue of great strength, for some considerable time, even minutes, to be followed by another wave reversing the current, yet the transition from one to the other never takes place suddenly; even the most rapid reversal of a big wave takes several seconds to accomplish. A similar sluggishness may be observed in all large changes of current strength; and it is suggested, without any hypothesis as to the cause of these earth currents, what keeps up such powerful currents for a long time in one direction at one place in at least the superficial portion of the earth (of course in closed circuits) of which portions find their way into telegraph lines, that the characteristic sluggishness is due to the electro-magnetic retardation as the currents in the earth change their strength and distribution.

(TO BE CONTINUED.)

Post Office Volunteers.—The 24th Middlesex (Post Office) Volunteers were encamped at Aldershot all last week, mustering between 400 and 500 strong, and took part in the manœuvres and drill, for which about 5,000 volunteers and as many regulars had been brought together. The signalling corps, made up exclusively of telegraphists, worked with the Royal Engineers, receiving instruction in the erection of wires and paying out of cable. On Friday, detachments of these men were assigned to the attacking and defending forces, maintaining telegraphic communication with their respective headquarters during the sham fight.

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ON THE ELECTRO-DEPOSITION OF CARBON, &c.*

BY G. GORE, LL.D., F.R.S.

The following experiments were made as attempts to electro deposit carbon, boron, and silicon :—

Experiment 1. A fused mixture of 200 grains of pure sodic hydrate, 170 grains of pure precipitated silica, and 610 grains of the mixed anhydrous carbonates of potassium and sodium was electrolysed by means of a current from ten Smee's elements, with a sheet platinum anode, and a thick platinum wire cathode. The conduction was free, and much oxygen, which relighted a red hot splint, was liberated at the anode. Dark streams flowed from the cathode; sodium was also set free, and if the cathode was only slightly immersed, bubbles of sodium vapour were emitted and took fire at the surface of the liquid. After one hour's action, the platinum anode had lost ·37 grains in weight. The cathode had a feebly adherent rough deposit of a dull jet black colour upon it. This deposit was subsequently washed and dried; a portion of it burned with a glow when heated to redness on platinum and left a minute residue of grey platinum. It also deflagrated with fused nitre below a red heat, and vividly by heating with potassic chlorate. It did not dissolve nor evolve any gas in a mixture of strong nitric acid and pure concentrated hydro-fluoric acid. It was therefore not silicon, but carbon containing a minute quantity of platinum.

As carbon was not readily deposited from the fused carbonates of potassium and sodium (*see* Experiment 4), whilst silicon was deposited from fused silico-fluoride of potassium (*see* Experiment 3), and as an excess of silicon fused with potassic carbonate sets free carbon, but silicon with an excess of the carbonate liberates carbonic oxide, the carbon liberated in the present experiment may have been a secondary result, and an effect of previously deposited silicon reacting upon the fused mixture. It was with an expectation of this effect that I employed silica in the mixture.

Experiment 2. I also electrolysed in a platinum cup a fused mixture of 475·2 grains of 97·1 per cent. sodic carbonate†, and 217·4 grains of borofluoride of sodium, by means of the same current, a sheet platinum anode, and thick platinum wire cathode. Conduction was free. Gas arose from the anode. A small amount of black deposit formed on the wire. After having been well washed the deposit was dried, put on a platinum dish, and heated to redness. It burned with sudden incandescence until nearly the whole was consumed. It was therefore nearly wholly carbon.

Experiment 3. I electrolysed in a platinum cup a fused mixture of 300 grains of 97·1 per cent. pure potassic carbonate and 442 grains of silico-fluoride of potassium by a current from ten Smee's cells, a sheet platinum anode and a platinum wire cathode. Gas arose from the anode, and at first only gas arose from the cathode also. After that, streams of black matter poured down from the cathode, and the latter acquired a blackish film, but subsequently became alloyed and fused on its surface. The deposit was therefore partly or wholly silicon.

Experiment 4. A mixture of 10 parts of pure anhydrous sodic carbonate and 13 parts of pure anhydrous potassic carbonate was fused in a platinum cup, and electrolysed by a current from eight Smee's cells and platinum electrodes at a red heat. Very free conduction occurred. Gas was copiously evolved from the anode, an abundant liberation of sodium occurred at the cathode. No gas arose at the cathode, but dark streams issued from it beneath the surface of the liquid. The anode became brown, but had lost only ·9 grain during one hour and a half's action. The cathode did not alloy with the sodium, but became brown, and was corroded at the surface of the liquid. A thin cathode of pure gold soon alloyed with the sodium, and melted at its extremity, although the temperature was below that of melting silver (probably in consequence of alloying with sodium); a thick one also gave off sodium vapour, alloyed and fused. A thick cathode of pure silver gave off sodium freely, but was soon cut in two at the surface of the liquid; its end became arborescent, as if it had absorbed vapour of sodium and expelled it again as it does oxygen. No free carbon appeared.

Experiment 5. I also electrolysed a mixture of 274 grains of pure sodic carbonate, 375 grains of pure potassic carbonate, both anhydrous, and 206 grains of crystallised boracic acid, in a similar manner at a red heat. There was free conduction, much gas from the anode, and an instant jet black deposit formed upon the cathode, and could be burned off by a red heat. Metallic sodium was set free at the cathode, especially during deep immersion. The anode was soon much corroded, and acquired a very smooth surface, and platinum was deposited upon the cathode. No free carbon was ultimately found.

Experiment 6. Potassic cyanide fused in a porcelain crucible was electrolysed by means of a current from 25 Smee's cells with a coke anode and an iron cathode. Free action occurred, much gas was evolved from the carbon, and some from the iron. A blackish deposit formed upon the iron and sank to the bottom. A platinum cathode dissolved quickly.

Experiment 7. Melted potassic cyanide in a porcelain capsule was electrolysed by means of a gas carbon anode, a thin platinum wire cathode, and a current from two cells of zinc and platinum in dilute sulphuric acid. No deposit occurred on the cathode in a quarter of an hour.

Experiment 8. I electrolysed distilled water by means of a current from 30 Smee's cells and a gas carbon anode of fine quality and a platinum wire cathode, the two electrodes being very close together. Very faint conduction occurred. The water became brownish in one hour; the carbon of the anode produced this effect. The anode was slightly disintegrated on the side towards the cathode. No deposit of carbon occurred.

Experiment 9. By means of a current from the same battery and a plumbago anode, I electrolysed a solution of potassic hydrate (with and without addition of oxalic acid). Free action occurred, and plenty of gas came from both electrodes. Saturated solutions of oxalic acid in hydrochloric acid, and in nitric acid, were also electrolysed by means of platinum electrodes. No carbon was deposited in either case.

Experiment 10. I electrolysed a solution of pure formiate of sodium in the strongest formic acid by means of a current from four Smee's cells and electrodes of platinum. A black film deposit formed upon the cathode. It was not platinum nor carbon, but apparently oxide of iron.

Experiment 11. Some oxalic acid was melted in its water of crystallisation, and the liquid electrolysed by the current from two small Smee's cells with platinum electrodes. Conduction was very feeble. Gas was evolved, but no solid deposit occurred.

Experiment 12. I passed an electric current during one week from four Smee's cells, by means of platinum wires, through pure very dilute sulphuric acid in a large V glass tube, one leg of which was kept full of a mixture of carbonic oxide and carbonic anhydride gases. The anode acquired a thin reddish coating, which dissolved soon after the current was stopped. No carbon was deposited.

Experiment 13. A cold saturated solution of pyrogallic acid in water was electrolysed by means of a current from 25 Smee's cells, a large platinum anode and a platinum wire cathode. Gas came rather freely from the wire, but none from the anode, and the liquid became quite brown by oxidation. No carbon was deposited.

Experiment 14. Strong hydrochloric acid containing a large gas carbon anode and a very small platinum wire cathode was electrolysed by means of a current from thirty Smee's cells. Free action took place. Much gas came from both electrodes; apparently chlorine from the anode, and hydrogen from the cathode. The cathode soon became black, but not when it was deeply immersed.

Experiment 15. A carbon anode in pure nitric acid was rapidly disintegrated by a current from two Smee's cells. The conduction was free. A gas carbon anode was also much disintegrated in a solution of potassic chromate by a current from thirty Smee's cells. Gas came from both electrodes.

* Paper read before the Birmingham Philosophical Society, July, 1884.
† The impurity consisted wholly of water

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Experiment 16. Hydrocyanic acid gas liquefied by cold, and containing a little water, was saturated with carbonic oxide gas, and a current from three to twelve cells of a Smee's battery passed through the liquid by means of two fine platinum wires. Gas was evolved from the cathode only. After three hours' action no carbon was deposited.

Experiment 17. Fuming Nordhausen sulphuric acid, also a syrupy solution of phosphoric acid, were saturated with dry carbonic anhydride, and then electrolysed by means of platinum wire electrodes, and currents from 112 Smee's cells in single series; carbon was not deposited.

Experiment 18. A saturated solution of oxalic acid in water was electrolysed by means of a current from ten Smee's cells, a charcoal anode and platinum wire cathode, in a hermetically closed glass tube. Gas was evolved, and the cathode became black. As the pressure increased, the conduction diminished and at a pressure of about 50 or 60 atmospheres the tube burst. By the electrolysis of a saturated solution of oxalic acid in alcohol with electrodes of platinum wire a thin black deposit was formed upon the cathode.

Experiment 19. The degrees of electric conduction resistance of distilled water and water saturated with carbonic anhydride at 60°F. were examined. No conspicuous difference was perceived.

Experiment 20. A current of coal gas was passed during fourteen days through a glass vessel over dilute sulphuric acid, the acid liquid being constantly electrolysed by means of four Smee's cells and platinum wire electrodes. A little gas was evolved from the wires all the time, but no signs of deposited carbon appeared.

Experiment 21. The electric current from a battery of three cells, composed of magnesium and palladium wires in water, conducted into water above a layer of CCl_4 by a purified gas carbon anode and palladium wire cathode did not set free carbon.

Experiment 22. The dry brown salt produced by exposing thin sheets of potassium to the vapour of carbonic bisulphide was dissolved in ether, and the solution electrolysed by a current from 25 Smee's cells and platinum wire electrodes. Much gas was evolved from the cathode, but no carbon set free.

Several of these experiments prove that carbon, boron, and silicon may be separated from their melted compounds by means of electrolysis; but although carbon was slowly deposited in several cases, in no instance was it obtained from an aqueous solution, or in a crystalline state.

ON THE ELECTROLYSIS OF FLUORIDE, CHLORATE, AND PERCHLORATE OF SILVER.*

BY G. GORE, LL.D., F.R.S.

By means of pure dilute hydrofluoric acid (prepared as described in *Phil. Trans.* Roy. Soc., 1869, p. 196) and pure oxide or carbonate of silver, a rather strong solution of pure argentic fluoride was obtained, and was then acidified by addition of pure hydrofluoric acid in order to fit it for electrolysis.

This liquid is a remarkably good conductor of electricity, and is decomposed with the greatest ease by employing electrodes of silver and an electric current derived from a single cell composed of zinc and platinum in dilute sulphuric acid.

I have elsewhere (*Phil. Trans.*, Roy. Soc., 1870, p. 235) described some of the phenomena attending the electrolysis of a strong aqueous solution of this salt not containing any free acid, such as the extremely rapid formation of a very thick coating of beautiful and bright crystals of silver upon the cathode, soon becoming half an inch in thickness and rapidly extending over the bottom of the vessel to the anode, and metallically uniting the electrodes unless the deposit is frequently removed. The increase of these crystals is so rapid with a strong solution and current that if the vessel is a small one it soon becomes half filled with them.

* Paper read before the Birmingham Philosophical Society, June, 1884.

There is, however, another phenomenon to which I now desire to call attention, viz., that whilst a thick and smooth anode of pure sheet silver in a suitable solution of potassic cyanide dissolves gradually away and retains its original whiteness, cohesive strength, and most of its original smoothness, until it has become extremely thin, a similar anode in the fluoride solution quickly becomes exceedingly rough, of a grey aspect, and very friable throughout its thickness, having lost its original degree of cohesive strength.

Imagining that this loss of cohesion might be due to some substance set free by electrolysis and absorbed by the silver, as in similar cases of absorption of hydrogen and other liberated ions at metallic cathodes, I took a tube of pure silver 2½in. deep, ⅝in diameter, and about 1 mm. thick, closed at the bottom by pure silver, and employed it as the anode, the upper end of the cup being tightly closed by cork, through which was fixed a slender platinum tube connected by an india rubber tube, with an open, slender, and bent glass tube containing mercury, in order to render manifest any diffusion of gas into the interior of the tube.

Under these conditions the liquid was electrolysed until a large hole was corroded in the tube; no signs of gas or odour, however, appeared, nor was the cork which closed the tube bleached or blackened. I conclude, therefore, that the loss of cohesion of the silver was not due to diffusion of liberated fluorine through the silver.

A solution of chlorate of silver was formed by adding to 1¼ oz. of aqueous chloric acid (containing as impurity traces only of hydrochloric acid or a chloride) 10 grains of argentic oxide; it nearly all dissolved. The liquid was filtered and then electrolysed by means of electrodes of pure sheet silver, and a current from two Smee's cells charged with a mixture of one volume of sulphuric acid and 50 of water. Conduction was very free for a short time; the anode, however, soon became coated with a black film, probably of peroxide of silver, which appeared to stop the current. Silver was freely deposited at first. The deposit was loose, and not very white. The anode corroded but slowly, and permanently continued nearly black. By employing one Smee's cell only, the deposit was more slow and more coherent, and remained attached to the cathode. The solution requires a feeble current, a large cathode, and much larger anode.

To form the solution of argentic perchlorate, fifteen grains of oxide of silver were added to one ounce by measure of aqueous perchloric acid; it nearly all dissolved. The liquid contained either hydrochloric acid or a chloride rather freely. The solution was then filtered and electrolysed by means of a current from two Smee's elements feebly charged and electrodes of pure sheet silver; copious conduction occurred. The anode quickly became black, as if peroxide of silver was formed, but the current did not much diminish. The cathode soon acquired a very bulky deposit of loosely adherent silky crystals of silver. The liquid was again filtered, and then diluted with half an ounce of water, and a current from only one Smee's cell now employed. The anode became less dark in colour, the conduction was still very free, and a smaller bulk of crystals was deposited. A wire of silver was now substituted as the anode, and the crystals removed. The anode rapidly corroded, and acquired a thick loose coating of black matter, which kept falling off; it then acquired a thick green coating, but evolved no gas. The solution is a remarkably good conductor. It requires a very large cathode, and a rather small anode.

NEW STEAMER.—The steamer "Saturno," which has just been completed by Messrs. A. and J. Inglis, of Pointhouse, in the Clyde, to the order of a River Plate company, for river service in South America, is lighted throughout by incandescent lamps, which have been fitted up by Messrs. William Harvie and Co., of Glasgow.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th August are £2,345, as compared with £1,968 in the corresponding period of 1883. The May receipts, estimated at £6,164, realised £6,296.

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THE ELEMENTS OF ELECTRIC LIGHT ENGINEERING.

BY E. C. RIMINGTON AND C. W. J. CRAWLEY.

(CONTINUED FROM PAGE 319.)

Having a characteristic curve drawn for a given speed to obtain one representing another speed,

Let the curve O P K M be the characteristic for speed of s revolutions per minute; we wish to obtain one of a speed of r revolutions.

From any point K in the curve drop the perpendicular K n, produce n K to p, making $n\,p : n\,K :: r : s$, or $n\,p = \frac{r}{s}\,n\mathrm{K}$; then p will be a point in the curve for the speed r. By taking various points along the curve O P K M and performing the same operation we obtain a curve O p L, which will be the curve required (*vide* Fig. 16, p. 139 *ante*).

The reason we make $\frac{np}{n\mathrm{K}} = \frac{r}{s}$ is that when the current is constant round the field-magnets, the magnetic field produced by the latter is also constant, and then E.M.F. varies approximately as the speed.

A given current is required through a given resistance to find at what speed the dynamo will require to be run.

Let R = given resistance in ohms, and C = given current = O C (Fig. 17.)

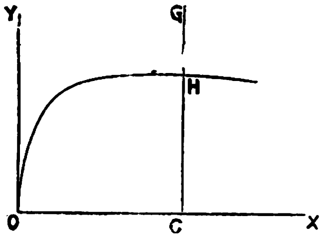

FIG. 17.

From C draw perpendicular cutting curve in H, on it mark off C G = C R volts, then

C H : C G :: speed for curve : required speed.

It often happens that we cannot keep the speed of a dynamo the same when we are varying the external resistance, particularly when it is driven from some engine that we cannot well regulate, such as a gas engine; in this case we need not trouble to keep the speed quite constant, but should keep it as much so as possible, and note it down against every observation of current and E.M.F. As we cannot well now obtain the total E.M.F's by setting off the terminal E.M.F.'s starting from the line of internal resistance as before, we must calculate the total E.M.F's from the formula

$$E = e + \rho\,C,$$

where E = total E.M.F., e = terminal E.M.F., C = current, and ρ = internal resistance of the machine.

Suppose we are drawing a curve for n revolutions per minute, and the number at which the machine was running when we took the observation was m, then the required total

$$\text{E.M.F.} = \text{total E.M.F. at } m \text{ revolutions} \times \frac{n}{m}$$

$$= \frac{n}{m}\left(e + \rho\,C\right).$$

If, for example, we are drawing a curve for 1,000 revolutions per minute, and when we took one of our observations we found the speed = 900, terminal E.M.F. = 70 volts, current = 20 amperes, $\rho = 1$ ohm. Then required E.M.F. $= \frac{1000}{900}\,(70 + 20) = 100$ volts.

So we set off along 0×20 divisions representing amperes, erect a perpendicular, mark off on it 100 divisions representing volts, and obtain a point in the curve.

To find the Electrical Efficiency of a Series Dynamo.

The electrical efficiency of a dynamo is the ratio of the electrical work done in the external circuit to the electrical work done in the total circuit.

Now, electrical work done in the external circuit = C^2 R, and the electrical work done in the total circuit = C^2 $(R + \rho)$. Therefore electrical efficiency $= \frac{C^2 R}{C^2 (R + \rho)} = \frac{R}{R + \rho}$, or is the ratio of the external resistance to the sum of the external and internal resistances, or total resistance. If in the circuit we have a secondary battery, we can represent it as an "ohmic" resistance, although the greater part of the opposition it offers to the currents is due to the back E.M.F. (*i.e.*, the E.M.F. tending to set up a current in the opposite direction to the charging current), and not a true ohmic resistance.

If there is a difference of E.M.F. between the battery terminals of ϵ volts, and a current of C amperes passing through it, it is equivalent to such a resistance as with ϵ volts at *its* terminals will also allow C amperes to pass, that is to a resistance of $\frac{\epsilon}{C}$ ohms.

But it must be remembered that this resistance varies with the current; it is, in fact, made up of two parts, the *true* internal resistance of the battery, and the resistance equivalent to the back E.M.F. divided by the current.

Suppose we have ten cells in series, each of two volts and ·01 ohm internal resistance, then the total *true* resistance = ·01 × 10 = ·1 ohm, and the back E.M.F. = 2 × 10 = 20 volts. When there is a current of eight amperes flowing, there is an E.M.F. at the terminals of 2 × 10 + 0·1 × 8 = 20·8 volts, and the ohmic resistance equivalent to this battery is then $\frac{20{\cdot}8}{8} = 2{\cdot}6$ ohms; but when there is a current of twelve amperes flowing there is an E.M.F. of 2 × 10 + ·1 × 12 = 21·2 volts at the terminals, and the ohmic resistance is now $\frac{21{\cdot}2}{12}$, or only about 1·8 ohm.

To formulate,—

$$R = \frac{\epsilon + \rho C}{C} = \frac{\epsilon}{C} + \rho \text{ ohms},$$

where ϵ = total back E.M.F.

ρ = total internal resistance of battery.

C = current passing through battery.

This also holds good in the case of a motor.

To Find the Electrical Work in the Circuit in Horse-power.

The work in the external circuit

$$= \frac{eC}{746} = \frac{e^2}{746R} = \frac{C^2R}{746}\,\text{h.p.},$$

e being the terminal E.M.F. in volts, C the current in amperes, and R the resistance of the external circuit (including all back E.M.F.'s, &c.) expressed in ohms.

Work expended in the coils of the dynamo $= \frac{C^2\rho}{746}$ h.p.

Total work in the circuit $= \frac{C^2 (R + \rho)}{746}$ h.p.

$$= \frac{E\,C}{746} = \frac{(e + \rho C)\,C}{746}\,\text{h.p.}$$

The mechanical efficiency of a dynamo is the ratio between the work in the external circuit and the work put into the dynamo as measured by a dynamometer on the pulley wheel, or

$$= \frac{e\,C}{746\,W}$$

where W = the power in horse-power applied to the dynamo as measured by the dynamometer.

It now remains to be seen how to arrange a small installation, employing a series dynamo as the generator. We will suppose that we are using incandescent lamps.

Incandescent lamps are usually arranged, as we have before stated, in multiple or parallel arc (Fig. 18), but if the E.M.F. given by the machine be double that required for each lamp, they must be put two in series, as in Fig. 19, the objection to this method being that we cannot extinguish a lamp without

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also extinguishing the one in series with it. In Fig. 18, A and B are the two main leads, one coming from each terminal of the dynamo; as many lamps as desired are arranged between them, one terminal of each lamp being connected to A, the other to B. Smaller wires, such as *a* and *b*, can be lead off from A and B, one wire being connected to A, the other to B, and more lamps arranged between *a* and *b*; other smaller leads, *a b*, can be made to branch off from *a* and *b*, and so on.

Suppose, as a practical example, we wish to put up 30 incandescent lamps, each requiring an E.M.F. of 50 volts, and taking a current of 1·4 ampere. If we arrange the lamps

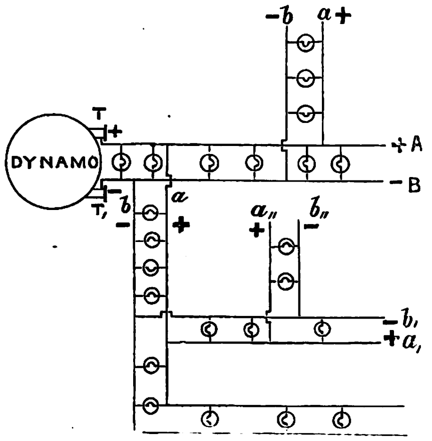

Fig. 18.

in single multiple arc, as Fig. 18, we shall require a machine giving an E.M.F. of 50 volts at the terminals when supplying a current of 42 amperes (1·4 × 30). If, however, as in Fig. 19, the lamps are arranged two in series, the dynamo must have an E.M.F. of 100 volts at the terminals while giving a current of 21 amperes (15 × 1·4).

We might again put the lamps three in series, in which case the dynamo would have to give an E.M.F. of 150 volts at the

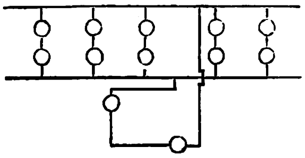

Fig. 19.

terminals when supplying a current of 14 amperes, but lamps are very seldom put more than two in series, and rarely that. We might, however, use lamps of higher resistance, *e.g.*, requiring an E.M.F. of 100 volts and a current of ·7 ampere.

When working incandescent lamps from a series dynamo it often happens that on turning on the switch and thus completing the external circuit the lamps do not light up, scarcely any current being generated by the dynamo. This phenome-

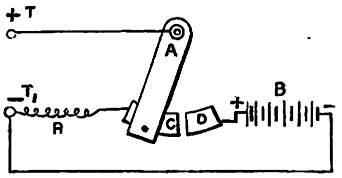

Fig. 20.

non arises from the fact that, as the resistance of incandescent lamps is about double cold what it is hot, the external resistance is above the critical resistance (as it is technically termed) for the speed at which the dynamo is being driven.

The critical resistance for a certain speed is the greatest resistance through which the machine when running at that speed will give any appreciable current; any very slight diminution in this resistance or increase in the speed will enormously increase the current.

In order, therefore, to produce sufficient current to light the lamps and thus lower their resistance, the dynamo must be momentarily circuited through a small resistance, or the speed must be increased for a short time, the best plan being the former, as it is not an easy matter to increase the speed with a well governed engine, and moreover the increase in speed will make the lamps burn beyond their proper candle-power.

When it is necessary to employ a series-dynamo for the purpose of charging secondary batteries the machine will have to be circuited through a resistance equivalent to the resistance of the batteries, as explained before, and then, when sufficient current is developed to allow the machine to get up a sufficiently high E.M.F. to overcome the opposing E.M.F. of the batteries, it should be switched on to them; this is best done by the employment of a two-way switch thus:—

T and T_1 being the terminals of the dynamo, R a convenient resistance, B the batteries. The arm of the switch A must be wide enough to touch the contact piece D before it breaks at C (Fig. 20).

LITERATURE.

Telegraphy. By W. H. Preece, F.R.S., and J. Sivewright, M.A. Third Edition. [Longmans, Green, and Co. 1884.]

When a book has reached a third edition it has proved its utility, for one can hardly imagine a book being bought merely for the sake of having it on one's shelves. The science of electricty is growing so rapidly that in a few years the young student will have to decide what branch he will study, for to study the whole will be the work of more than a lifetime, and as the science extends the arts based on the science will extend and diverge likewise. Indeed, the telegraphist cannot hope to be at the same time master of "electric light operations" and of "electro-chemical or electro-metallurgical operations." Each of these subjects, then, demands special manuals. The book before us deals with the principles and practice of telegraphy, restricting itself more directly to land telegraphy, the authors evidently and rightly thinking that submarine work deserves a special manual. Such a manual would be a useful adjunct to the one before us. The authors of this work have probably had far more experience, and are better able to judge what experience has found to be right than most people. Hence, with the exception of the use of the term "quantity" in the second paragraph—an exception we have taken before—we are not prepared to combat the views expressed. The principal additions to this edition will be found in the chapters on "The Telephone," "Fast Repeaters," and "Quadruplex Telegraphy," also a table on the "Imperial Standard Wire Gauge," at the end of the book. The chapter on "Commercial Telegraphy" is omitted, although at p. 281 the headline is still retained. The alterations up to p. 281 are not very important. The information given is just that required by every one commencing the study of telegraphy, and is absolutely essential if a real knowledge of the work is desired.

A Handbook of Electrical Testing. By H. R. Kempe. Third Edition. [E. and F. N. Spon. 1884.]

This is by far the best book on the subject of testing in English, or indeed in any other language. The work is almost perfect. Perhaps we might suggest the addition of descriptions of Saunders's key, and FitzGerald's method for measuring the internal resistance of batteries. Of the latter Mr. Sprague writes it "is by far the simplest." The information given is exceptionally clear and full, while too great praise cannot be given on account of the general arrangement, correct mathematics, and careful endeavour to always show the why and the wherefore of the operation, as well as its possible accuracy. It is needless to write further of this new edition, except that we may say the author has taken the opportunity to add several valuable tables and descriptions to those in the second edition, and to impress upon students the necessity of studying this work thoroughly, in order that they may not only carry out tests in a purely mechanical manner, making the connections as they have been told to make them or seen others make them, but that they may obtain a real intellectual insight into the operation.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes ... 333
The Induction of Currents in Cores. By Oliver Heaviside. (Continued.) Illustrated ... 338
On the Electro-Deposition of Carbon, &c. By Dr. G. Gore 340
On the Electrolysis of Fluoride, Chlorate, and Perchlorate of Silver. By Dr. G. Gore ... 341
The Elements of Electric Light Engineering. By E. C. Rimington and C. W. J. Crawley. (Continued.) Illus. 342
Literature ... 343
Lightning Conductors ... 344
Correspondence ... 345 and 346
The Health Exhibition.—VI. 346
Incandescent Lighting. By T. H. Seymour Hawker. (Continued.) Illustrated ... 347
The Trinity House Experiments on Lighthouse Illuminants. Illustrated ... 349
Lightning Flashes. Illustrated ... 350
Experiments on the Efficiency of Incandescent Electric Lamps. By H. B. Gale. (Concluded.) ... 350
Dynamo-Electric Generators. (Continued.) ... 351
Ships' Lights ... 352
Electric Lighting at Greenock 353
Thunderstorms ... 354
Legal ... 354
Companies' Meetings—
The River Plate Telephone and Electric Light Company ... 355
Companies' Share List ... 356

ANSWERS TO CORRESPONDENTS.

J. CHAPMAN.—*If you refer to "The Electrician" of June 28th last, p. 150, you will find Dr. Gore's remarks upon aluminium. The information there given, and the references made, will no doubt be amply sufficient to indicate to you all that you require to know.*

LIGHTNING CONDUCTORS.

"The free and frequent use of the testing galvanometer is, indeed, the natural consummation of the beneficent work which was initiated by Franklin one hundred and thirty-five years ago." Such are the concluding words of the *Edinburgh Review* in its article on lightning conductors, to which we promised a short time ago to refer at greater length when an opportunity arose. And, indeed, although the writer has given us an interesting historical *resumé* of the subject, from the time of Hawksbee, Gray, and Franklin to the present day, and has gathered together a great deal of useful information from sources hitherto widely apart, we rise from the perusal of his article with our admiration of the electrical celebrities of the last century greatly enhanced, nothing material in the same direction having been discovered by their modern successors. A later study of the conditions necessary for protecting buildings from lightning by means of metallic conductors has perfected the system, at least theoretically, and the invention of apparatus for testing its efficiency has rendered the process simpler; but from the moment when Franklin, who had had his attention drawn to the identity of static and atmospheric electricity, observed that "electric discharge was attracted by points," and determined on "ascertaining whether lightning had not the same tendency," the whole range of subsequent inquiry was practically anticipated. To say this is no reflection on modern science, for the pointed lightning conductor attached to Franklin's house in 1752 fulfilled all the functions of a lightning conductor, nothing better being either practicable or necessary.

But between the discovery of a law with a useful application and its general adoption there is a wide gulf, and for reasons which reflect no discredit on anybody in particular the unquestionable utility of Franklin's device failed to meet with general acceptance until sixty or eighty years after his time. The suggestion was taken up both in England and in France, but apparently only by individual enthusiasts; whilst in America its more extended adoption led to some accidents which were natural under the circumstances, and which provoked equally the denunciations of pulpit and press. Small blame to either for this, seeing that even in England an engineer in the service of the British Government as recently as 1826 recommended the removal of lightning conductors from all public buildings as dangerous expedients; and later, in 1838, they were actually so removed from the arsenals and magazines in India by order of the Governor-General. The truth was, and it is the one truth which remains still to be enforced at this day, that unless the conductors were properly erected they were a source of positive danger. Several conditions were necessary for complete success, failure in respect to any one of which might result in disaster. The conditions were broadly understood, but they were not always complied with, nor was their relative importance at first fully appreciated. Accidents from lightning despite of conductors were not of unfrequent occurrence then, and they are not infrequent now; the difference is that after a long course of years we have acquired such confidence in the protector itself that nothing but imperfection in the method of applying it will account for its failure.

But the process by which this confidence is inspired was a long one; not only had unprotected buildings to be struck whilst protected ones escaped, but the cause of protected buildings not escaping had to be investigated and proved. A long series of observed facts had to be compared before sceptics were convinced. Some capital evidence on one or two highly important points was supplied by the navy. It was the practice on board ship to drag up a chain to the masthead, and let it hang several feet in the water. The captain who first ventured on this expedient must have been a bold man, with more faith in science than in the Providence which sailors are supposed exclusively to trust in. Whenever a ship so equipped was assailed by lightning she invariably escaped uninjured, but it generally happened that the chain was shivered to atoms. This was an expensive but instructive form of lightning conductor. Evidently a perfectly continuous conductor was needed, and this, coupled with the perfect outlet which the sea afforded, resulted in complete immunity from accidents of that kind. A perfect conductor from the highest point to a perfect conducting medium at its lowest were, then, the main conditions of efficiency. Applied to structures on land protection is as certainly and as easily obtainable. The great thing is to get these conditions enforced and maintained.

It is true there are some variations of method, and at least one that may be called rival and revolutionary. Professor Melsens' cage-like system for the protection of that precious architectural gem, the Hôtel de Ville, at Brussels, is one that errs, if it errs at all, on the right side, by connecting so many

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points of the building with abundant outlets to earth—exceeding in these safeguards anything that has been thought or found to be necessary elsewhere. Again, there is some divergence of opinion as to the dimension of the wire; and some valuable reminders are given by the Edinburgh reviewer concerning the employment of galvanised iron, the coating of which, being thin and the better conductor, is apt to get fused, and in any case may mislead as to the conducting capacity of the wire in mass. But on the whole there is a general agreement among experts growing closer every day; and the heretical suggestion of Major Parnell to do away with tall rods, substituting for them earth-buried plates, with short earth points surrounding the building, may be dismissed as lacking any substantial evidence to support it.

Turning, however, to the reviewer's own observations where he leaves history for criticism we are not sure that we can always agree with him. He is, we think, unduly severe on the rules put forward by the Conference of the Meteorological Society in 1882. It is true that the rules added nothing to our previous knowledge, and might have added something if the committee had investigated instead of framing rules straight off. But for what they profess to be, however, the rules are of general utility, and not seriously open to misconstruction. There is no comparison between the resistance created by bad joints and that of lengthening the conductor. For lightning rods the differences in length are not great, and the variation of their resistance on this particular account is less appreciable than the reviewer seems to imagine. We cannot agree with him either in advising the utilisation of gas or water pipes for "earth" purposes; indeed, his paper is weak generally on the subject of earth, and in this recommendation is a dangerous adviser, as his own account of the fire at the Dolphin, Chichester, might have warned him. Some fuller statement of facts relating to the risks to buildings from lightning incurred, as he alleges, from the affixing of overhead wires, would have been very acceptable. But, as a whole, the current number of the *Edinburgh Review* will well repay a careful perusal by all who are interested in protecting life and property from the destructive effects of lightning.

CORRESPONDENCE.

CAPACITY OF A CONDENSER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: [*See* p. 297.] So far as the possible objection to the method that the condenser may not become completely charged in the time allowed, that is removed by seeing in any experiment that the resistance external to the condenser is sufficiently small (when being charged) to allow of its becoming practically fully charged, barring the residual phenomenon of absorption or viscosity, in less than half the period of the fork. In Mr. Glazebrook's experiments the resistance external to the condenser was always under 1,000 ohms, which, with $\frac{1}{3}$ microfarad capacity, would make the time constant $\frac{1}{3000}$ second. This is about $\frac{1}{12}$ of the shortest semi-period (period $\frac{1}{128}$ second), so that there was ample margin throughout. But, other things being the same, the frequency could not be much raised without destroying the margin of safety.

The condenser being fully charged for, say, $\frac{1}{3}$ of the whole time, and the charge being always of the same kind, must cause viscosity to have some effect on the result, nearly the same at different speeds, presumably making the apparent capacity slightly lower than the true instantaneous capacity.—Yours, &c., OLIVER HEAVISIDE.

WHAT IS ELECTRICITY?

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. D. G. FitzGerald has often in your columns asserted, substantially, that electricity is a material substance. I have read so much of his vigorous writing that I am sure he feels he has good reasons for his assertions. Some years ago he began a series of articles in *The Electrician* on this subject, but did not finish it; it seemed to me that he got lost in mathematical puzzles. I cannot see how this problem can be solved by the twisting about of mathematical formulæ, or the enunciation of theories which lack experimental proof.

If Mr. FitzGerald will make it his convenience and pleasure to favour *The Electrician* and its readers with a series of articles on this subject, giving without reserve his ideas of the nature of electricity, arguing and explaining from a physical basis only, and citing experimental evidence in proof of the same, he will delight and instruct your readers, among whom is, yours, &c., SAMUEL PURNELL.

San Francisco, California, Aug., 1884.

SIEMENS' ELECTRO-DYNAMOMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your publication of to-day, at page 318 a description is given of "the Siemens Electro-Dynamometer," in which, with the object of avoiding the variation due to loss of magnetism common to other galvanometers, a fixed coil of insulated wire is employed to actuate a suspended coil.

I shall be obliged by your pointing out that this principle of constructing standard galvanometers was patented by my brother, Mr. Edward Bright, and myself so long ago as 1852, as may be seen by reference to the specification and drawings of the patent No. 14,331 (Old Law).—Yours, &c.,

CHARLES T. BRIGHT.

31, Golden-square, London, Aug. 16, 1884.

THE RISE IN TEMPERATURE OF ELECTRIC LIGHT LEADS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In *The Electrician* for June 28th "Student" writes that he cannot understand the formula given at p. 213 in Munro and Jamieson's "Pocket Book of Electrical Rules and Tables," viz.:—

$$\tau^0 = \frac{4\rho}{Jh\,\pi^2} \cdot \frac{c^2}{d^3}.$$

Where τ^0 = the increase of temperature Centigrade of the wire aboveits surroundings.

ρ = the specific resistance, or the resistance of 1 cubic centimetre of the conductor, given as 1,700 *absolute* units of resistance for pure copper, or ·0000017 ohm at 10° C. or 50° F.

c = the current strength in *absolute* measure, *i.e.*, amperes $\times 10^{-1}$.

J = Joule's equivalent, or $4 \cdot 2 \times 10^7$ ergs, *i.e.*, the amount of energy equivalent to the raising of one gramme of water from 0° to 1° C., or one gramme-degree (*see* p. 16).

h = the heat emitted from the surface of the conductor per square centimetre per second by radiation and convection, given as 2×10^{-4} for bright copper.

$\pi^2 = 9 \cdot 8696$.

d = diameter of conductor in centimetres.

Using the above values for ρ, J, h, and π, he finds correctly that

$$\tau^0 = \frac{c^2}{d^3 \times 12 \cdot 192} \text{ in degrees centigrade;}$$

but here he stops, because he has failed to notice that, as ρ

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was taken in absolute measure or C.-G.-S. units, so c must also be taken in absolute measure.

If ρ were in ohms, then c would be amperes.

An example or two will, however, make this clear to him. Suppose the case of a bright copper wire ·254 centimetre diameter (*i.e.*, $\frac{1}{10}$in., or very nearly No. 12 Board of Trade gauge), having a current of 10 amperes passing through it, by what temperature will the wire exceed that of the atmosphere which is at 10° C?

$$\text{Here } d = \cdot 254 \quad \therefore d^3 = \cdot 016387,$$

$$c = 10 \text{ amperes} = 10 \times 10^{-1} = 1 \text{ C.-G.-S. unit.}$$

$$\therefore \tau^0 = \frac{1^2}{\cdot 016387 \times 12\cdot 192} = 5^\circ \text{ C. or } 9^\circ \text{ F.}$$

If "Student" will look at the table given at p. 214, he will find 9° F. as the rise of temperature for this wire with a 10-ampere current flowing through it.

Again, taking the same wire, but passing a current of 20 amperes through it, we find

$$C = 20 \text{ amperes} = 20 \times 10^{-1} = 2 \text{ C.-G.-S. units;}$$

$$\therefore \tau^0 = \frac{2^2}{\cdot 016387 \times 12\cdot 192} = 20^\circ \text{ C., or } 36^\circ \text{ F.,}$$

which also corresponds with the figures in the table, page 214. The whole of the tables pp. 214 to 216 have been so calculated. Every factor in the formula is well known, except h, the heat emitted per square centimetre per second. We find Professor Forbes, who adopts this same formula in his well-known paper read before the Society of Telegraph Engineers last March (*see Journal* of the Society, No. 52, Vol. XIII., p. 238), uses for h, in the case of *polished* copper, the constant $1{\cdot}68 \times 10^{-4}$, or ·000168, and for *blackened* copper 3×10^{-4}, so that Sabine's value for *bright* copper, viz., 2×10^{-4}, is in tolerable agreement therewith. Perhaps Dr. Fleming, who answered "Student" in your issue for June 5th, may have by this time so extended his experiments as to be able to give us a more exact determination for h, or constructed a formula to agree with his experiments.

The value given by Professor Forbes in his paper already referred to for the specific resistance ρ is 0·000001642 ohm at 0°C., and the resistance for any temperature $t°$ above 0°C. of a cubic centimetre of pure copper is therefore

$$0{\cdot}000001642 \left(1 + \frac{\cdot 38t}{100}\right)$$

which gives the number we used, viz., ·0000017 ohm, or 1,700 C.-G.-S. units, at about 10°C. or 50°F.

You were rather severe, Mr. Editor, in your review* of the book upon the tables calculated from the formula referred to by "Student," but the fact of the matter is this, that Sabine's data was the only information we could find when compiling this part of the book, and we shall be glad to substitute anything better whenever it comes out. We have corrected all the mistakes brought to our notice for the second edition, and we hope you will keep your promise by again referring to the book, and, perhaps, kindly point out any errors or improvements not already noticed by other reviewers, as we wish to keep the book up with the times, and render it correct. We should have answered "Student" sooner, but we have been absent for some time.—Yours, &c.,

Aug. 20, 1884. MUNRO and JAMIESON.

* We have not yet reviewed the work. What we did was to notice it in order that readers should know of its existence, believing that such a work was wanted, and would be duly appreciated. We could not see the utility of certain tables, and said so, imagining that the useless ought to give place to the useful. Our intention was not to be, or appear, severe, merely to indicate the direction of our thoughts. The value and the failings of such a work can only be ascertained by the lapse of time and constant use, and we certainly intend referring to it again in due course. —ED. *E.*

ELECTRIC LIGHTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I thank you for the insertion, in your last issue (this day's date), of the correspondence I sent you on the 13th inst. One or two errors, however, having crept into the letterpress, I beg to hand you herewith a corrected copy, and to request that you will be kind enough to make the necessary rectification in your next impression.—Yours, &c.

J. E. PICKERING, Secretary.

The National Company for the Distribution of Electricity by Secondary Generators, 18, Warwick-street, Regent-street, W., Aug. 16, 1884.

ERRATA.—Third paragraph from bottom of first column, page 321, for "118 wires (No. 21)," read "48 and No. 26." The equation at the bottom of this column should be

$$E_P = 100\frac{13{\cdot}000}{14{\cdot}500} = 89\%,$$

and not as given. In the third paragraph of second column, for "8 a.m." read "1 a.m." In the next paragraph, fifth line, for "cost of the plant" read "rest of the plant." In the concluding paragraph, ninth line, for "supply" read "employ."

[The copy, and not the printers, is to blame for the above mistakes.—ED. *E.*]

CITY AND GUILDS OF LONDON INSTITUTE EXAMINATION IN TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The results of the City and Guilds of London Institute examinations of last May have just been issued. Can any one explain to me the strangely erratic character of those in *telegraphy?* In this and in previous years I have found in this subject that it is utterly impossible to even approximately forecast the results from a knowledge of the aptitude of each student. Such a process I have always found possible in connection with Science and Art Department examinations. But in *telegraphy* everything is a surprise. The student who is poor both in theory and in practical work quite as frequently takes a good place as does he who has an aptitude for both; and, indeed, in my experience, it happens as often as not that the latter is ignominiously plucked, although there may be every reason to believe that he has worked a first rate paper. Can anyone offer a solution of these apparent inconsistencies?—Yours, &c.,

20th August, 1884. R.

SUPPLEMENT No. 5.—CORRECTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The diameters of Nos. 32 and 33 are printed as ·108 and ·100 instead of ·0108 and ·0100 respectively.—Yours, &c.,

London, E.C., 18th August, 1884. A. DALGLEISH.

HEALTH EXHIBITION—VI.

Most visitors to the Exhibition cannot fail to be struck with the gorgeous lighting of the entrance hall. The grand electrolier of Verity's is as attractive now as it was at the Crystal Palace. Passing from the entrance into the South Gallery the style is completely altered—ornateness gives place to the utmost simplicity. From an æsthetic, and indeed from any point of view, the simplicity is too simple, and although one is struck with the long range of lamps—for rafter beyond rafter we have "those twinkling points of fire"—they certainly seem to require a little different arrangement. We have heard views expressed quite the opposite of these, maintaining that alteration would spoil the effect. At any rate, in this gallery there are about 1,100 Swan lamps exhibited by Messrs. Siemens Brothers and Co. Besides this part of the building, Messrs. Siemens light the Conservatory and the Prince of Wales's Pavilion. The lighting of the latter is almost perfect, and the visitor acknowledges the ingenuity displayed. Here, too, the

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great value of the electric light is seen in the non-destruction of the delicately tinted ceiling and wall decoration. The lamps used in the Pavilion are Swan lamps, but some Siemens arc lamps will be found in the engine room and in the Conservatory.

The electric current for the lamps in the South Gallery is generated by Siemens's alternate current machine, using an exciter for the field-magnets. Two such machines of the type known as W_{11} are used, the exciter in each case being of the type known as D_7. The output of the W_{11} machine is about 30,000 volt-amperes, with 1,100 revolutions of the armature per minute, requiring a total of from 50 to 60 horse-power to drive the machines. The circuits of the two machines are independent, so that if anything goes wrong with one machine the lamps only on alternate ribs of the roof would be affected. The difference of potential between the mains is the same at the last lamp as the first, owing to the adjustment of resistances, so that all the lamps should be of the same brightness, that is providing the filaments are all homogeneous and similar. Fusible cut-outs are placed at all points where a branch wire is joined up to the main, so that should there be any accident and too great a current to the branch, the cut-out acts and saves the branch.

In the Conservatory there are four arc lamps, each of about 4,000 actual candle-power. The four lamps are arranged in parallel arc, and the current is generated by one SD_0 self-regulating machine.

The SD_2 machine is said to have an output of 3,600 volt-amperes, and to require some 7½ horse-power. All the machines will be found in the electric light engine room, and the necessary power is obtained from the main shafting, driven by the double cylinder engine of Messrs. Davey, Paxman, and Co. Besides these machines, there is another Siemens machine in the engine room, which has been christened by the men about the place as "Jumbo." This machine is used in the fountain illumination, and will be mentioned hereafter.

The HAMMOND ELECTRIC LIGHT AND POWER SUPPLY COMPANY exhibit excellent examples of their work and lighting system. The principal feature is a 43in. diameter helix Ferranti dynamo, in which are embodied many of their recent improvements. This is a beautiful machine, and as far as we know has done its work well. The frame is of the new service type, and of great strength as well as considerable elegance. The field is composed of two castings bolted together, each containing a crown of 24 electro-magnets, the poles of which are only 9-16ths of an inch apart, being coupled in two parallels within an exciting current of 33 amperes; the field is therefore very intense. The armature is built of $1{\cdot}5 \times 9{\cdot}5$ mm. bare copper strip, insulated only between the layers, and firmly based on a wide flanged phosphor bronze hub. The armature is in three parallels, giving an internal resistance of ·02 ohm, and at a speed of 590 revolutions per minute generates an electromotive force of 400 volts. The current, which is sufficient for some 1,500 lamps, is collected by centrifugal mercury collectors, consisting of copper discs, revolving on annular troughs of mercury. These are simply perfect in their action, and give no trouble whatever. The lubrication is effected throughout from one oil vessel, from which the lubricant is fed at pressure through a series of nickelled copper tubes, fitted with transparent dropping cups, regulated by separated taps. The supply of oil is thus capable of being regulated to any part at will. The machine, together with its exciter, is bolted on a massive bed-plate, the motion being communicated from the former to the exciter by one of the company's new flexible shaft couplings. This coupling is very neat and effective, and seems to deserve the good opinions it has obtained. As a whole this company's exhibit shows a very promising appreciation of the practical exigencies of electric lighting, and is carried out in a thoroughly substantial engineering manner.

The company is also exhibiting a 40-light Brush machine and lamps, the steadiness with which the latter burn proving that the old complaint of flickering can be perfectly cured. This company is also exhibiting their Swinburne incandescent lamp, having it is stated an efficiency of 60 watts per 20 candle-power.

INCANDESCENT LIGHTING.

BY T. H. SEYMOUR HAWKER.

(CONTINUED FROM PAGE 247.)

Having considered the rudimentary principles on which a circuit is planned, we can turn our attention for a time to the dynamos, lamps, and other apparatus which are employed. The actual theory of construction and description of mechanical details I will leave for the present, as there has been so much reference to these matters in the columns of *The Electrician* lately, and I may simply be reiterating or anticipating the writings of others.

In all cases of electro-magnetic induction an electromotive force, or difference of potential, is generated between two points (which in the dynamo are practically at the armature terminals) by the variation of the magnetic potential of the conductive part between them.

"Potential" is defined as the ability to perform work. Hence the unit magnetic potential is the energy necessary to bring a magnetic pole of unit strength from an infinite distance up to unit distance from a similar pole.

At unit distance from a pole of strength n the potential will therefore be $= n$, as that pole will be capable of performing n units of work in repelling a unit pole to an infinite distance. The potential will vary along the lines of force of the field maximum to zero.

Any conductor placed in a magnetic field will at each point of its length assume the potential of the field at that point which it occupies. Variation of position will vary the potential of the parts of the conductor, necessitating the transformation of a quantity of energy or performance of work equal to $V_1 - V$. If the circuit is open the equivalent will appear in the form of an E.M.F., which is probably merely a molecular tension, having difference of values at the two extremities of the conductor; and if closed as the product of the electric current which will be produced into the active E.M.F. driving it.

This is the general dynamic principle evolved in induction, and from this point of view we can describe a dynamo as a machine arranged so as to nearly continuously vary the potential of the parts of its inductor or armature, and give a high value of energy evolution in a given time; or $\frac{V_1 - V}{t}$.

Adding to the length of the conductor, which is varying its position in the field, will increase the E.M.F. produced by increasing the linear dimensions of the active portion, but the accompanying increase of resistance will diminish the current factor of the energy flow—C E.

Great lengths of armature conductor are therefore employed to produce high E.M.F.'s, and lesser lengths and wider sectional areas for large currents.

The E.M.F. produced is also inversely proportionate to the time t during which the energy $V_1 - V$ is evolved, and hence for large E.M.F.'s high speeds are necessary, while lower speeds will do for lower E.M.F.'s, even if by reason of the lowness of internal resistance the current produced be large.

For incandescent lighting low tension machines giving large current are now universally employed, except where the exigencies of circumstances are more regarded than a consideration of the relative merits of the series and parallel circuit system. When, however, single high resistance lamps of, say, 200 volts can be obtained of good quality, there will be doubtless a general adoption of this E.M.F. as the maximum allowable by the Board of Trade, in order to obtain the advantages of smaller cables and reduced heat waste attending the corresponding reduction of current.

By increase of speed, machines even of very low resistance, *i.e.*, short length of armature conductor, may be caused to give high E.M.F., and the energy output of dynamos of this type is very great as compared with their mass of inducing metal or weight of copper in armature.

They have, however, the disadvantage of great wear and tear to plant, unless carefully driven, and are often objected to on this account.

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The practical difficulties attending the multiplication of speed by machine banding also militate against the success of the high speed dynamo, but the attention at present being paid to the development of high speed engines promises soon to reduce this objection, by substituting direct coupling to engines.

It is necessary that the speed of a dynamo should be a determinate function of the current flowing in the external circuit, or the E.M.F. at its terminals.

With a constant rate of energy supply a steady unvarying speed should be maintained, which should be automatically reduced or accelerated as the work diminishes or increases.

This is the function of an electrical governor, and has for its principal reason that the E.M.F. is varied by the speed, and it is required to keep the E.M.F., which varies with the resistance of the external circuit, constant throughout any possible variations of current by alteration of the number of lamps lighted.

In commutator or continuous current machines, however, another reason prevails. The brushes or collectors are adjusted to a diameter of the commutator relative to the field poles known as the diameter of commutation. This most advantageous angle for the contact of the brushes is the angle whose tangent is the ratio of the strength of the field polarity to that of the polarity induced by the passage of the current. When, therefore, the masses of iron of the field and armature cores are of unequal saturation, any cause tending to alter the current will also vary the angular lead and throw the brushes relatively out of position, causing sparkling and loss of efficiency.

In self-exciting machines this is still more marked. Constant, or rather regularly varying speed is a necessity, therefore, for both reasons, though the variation of lead can be much reduced by separate excitation, and is entirely absent with alternating current machines, owing to the nature of their collectors.

The effect of the enormous change of lamp resistance with different temperatures of the filament of course tends to increase and exaggerate any variation of lead when possible.

The question of the relative merits of continuous and alternating currents for electric lighting has been largely discussed of late years, but as each system has its special advantages and disadvantages, circumstances can alone decide which is most generally preferable. As a general rule alternating currents are more easily handled than continuous, being less liable to strike destructive arcs at switches, &c., and the use of block or mercury collectors making contact with revolving continuous bosses much simplifies the generator while necessitating less attention when running. Notwithstanding the extra cost of separate exciter which is necessary with the majority of alternating machines, the simplified construction enables them to be made much cheaper than commutator machines. Again, instead of the very cumbersome and wasteful resistances which are necessary with continuous currents, when it is required to turn down or graduate the lights, advantage can be taken of the opposing E.M.F. which is induced when a continually varying current is brought closely parallel to another portion of itself. This device is so effectual that, by the aid of a small apparatus and switch combined, in use by the Hammond Electric Light and Power Company, consisting of a volute of copper tape, greater or less lengths of which can be thrown into circuit, several hundred lamps can be regulated to any brilliancy from full power to dead out, and this by simple counter E.M.F.—without waste.

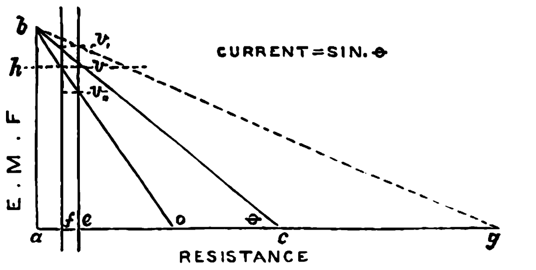
On the other hand, the rapid variations of the alternating current, although so useful in some cases, almost entirely unfit it for electro-magnetic or electrolytic work. The self-induction of the alternating current is often so great that a coil of a few ohms resistance can induce a reversed E.M.F. of such magnitude as to so nearly neutralise the direct E.M.F. that, with 100 volts at the terminals, only a fraction of an ampere will pass. Moreover, the alternating current is very active in inducing Foucault or "eddy" currents in neighbouring conductors, and thus wasting energy. The choice of a machine to suit the conditions prevailing at any special installation depends a great deal on the method of excitation.

With a separate exciter is is only necessary to choose a resistance of armature equal to or not exceeding that value which will give the previously determined circuit efficiency by its ratio to the aggregate resistance of the hot lamps. Separate excitation, by avoiding the reactive effects of derived exciting currents, imparts considerable steadiness to a plant, making the light less sensitive to variation of driving speed and external resistance.

The exciter should be chosen to drive the maximum safe current through the field coils, and this should give as nearly as possible saturation of the iron on the field magnets. When the exciting current is derived from the generator itself very opposite attributes prevail, according as the field is connected in series with or as a shunt to the external circuit. With the series machine the field is fed with the entire current generated, and anything which affects this current, such as variations of E.M.F., or external resistance, must also react on the E.M.F.-generating-power of the machine. Thus an increase of resistance decreases the current, and unless the iron be supersaturated reduces the intensity of the field, which again reduces the E.M.F., and so on, until equilibrium is established.

With incandescent lighting on the parallel system of connection, on decreasing the number of lamps the resistance is increased, and the E.M.F. at the lamp terminals increased, and *vice versâ*. Therefore, within certain limits the attributes of the series dynamo in decreasing its E.M.F. with increased external resistance are advantageous, as the tendency is to keep the E.M.F. at the lamps constant irrespective of number.

The usual characteristic diagram of a circuit will illustrate this. Let $a\,b$ represent to any scale the E.M.F. of a generator at a certain speed, and let $a\,f$, $f\,e$, and $e\,c$ similarly represent the resistances of dynamo, leads, and lamps respectively. Then the line $b\,c$ will represent the fall of E.M.F. along the resistances.



Circuit Characteristic Diagram.

If the number of lamps be halved, the resistance of the latter portion will be doubled, and the fall of potentials represented by the line $b\,g$. This cuts the ordinate at the lamp terminals at a point, v, much higher than previously, as the same E.M.F. is running down through a higher resistance. The E.M.F. at the lamps will thus be excessive, as the normal circuit will necessarily have been arranged so that with a total E.M.F. of machine $= a\,b$, the E.M.F. $f\,v$ at the lamps will be just sufficient, the surplus E.M.F. $b\,h$ being allowed in order to drive the current through the leads and machine.

Similarly, on doubling the number of lamps the resistance through which the E.M.F. runs down is less, and the internal and fixed resistances absorb a greater proportion of it, leaving a less and insufficient E.M.F. at lamps. It must be evident that the ratio in which the lamp E.M.F. will be effected depends greatly on the nature of the circuit—particularly the ratio of fixed to lamp resistances—and therefore in order that the fault may be corrected by the use of a series generator we must be able to control definitely the individuality of the machine.

Now, in the first case, it is required, by using a sufficient length of conductor wrapped round the field-magnets carrying the total current, to excite these magnets to, or nearly to, saturation. The E.M.F. at the lamps varies with the ratio of the fixed and lamp resistances, and in order to correct this the current must vary similarly. In the series machine, however, the variation is in a much greater ratio, and requires to be modified by "compounding" with an additional shunt-

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wound coil in order to attain perfect self-regulation. I hope in a future article to consider fully the proportioning of the compound and other machines.

In using a plain shunt machine the tendency is to exaggerate the effect produced by varying the number of lamps running. Reducing the number, for instance, increases the external resistance, and by driving more current through the field coils increases the magnetisation, unless saturation is already attained, and thereby enables a *higher* E.M.F. to be generated when a reduced is alone wanted. Many so called "automatic" devices have been proposed and tried for the purpose of compensating for these defects, by the insertion of resistances or shunting of the field, but all I have met with have been unsatisfactory and clumsy, and as even the best self-compensating or compound wound machines have a considerable range of defect I advocate in all cases a regulation by *speed of driving* depending on a good electrical governor for acceleration when E.M.F. is too low at the lamps, and retardation when too high. The strength of an electro-magnet depends directly on the length of conductor in its coil and the strength of current carried thereby. The effect in producing a magnetic pole is varied also by a constant depending on the nature and mass of the iron constituting the core, and is inversely as the square of the mean radius of the convolutions of the conductor from the axial centre of mass of the core.

Or $M = \frac{a\,C\,L}{r^2} \ldots$ and $\therefore L = \frac{M\,r^2}{a\,C}$,—which gives the length of a conductor carrying a current, C, necessary to magnetise a bar of magnetic constant a and radius r to a polar strength M.

The constant a is determinable experimentally, and is for a cylindrical core of the form $a = k . \frac{2\,C\,r}{Z\,r^2}$, Z being length of core, r radius, and k coefficient of magnetic induction.

A knowledge of the minimum size of wire which can safely carry a normal current C will give a clue to the resistance per length L of the winding of a field-magnet. The aggregate resistance of shunt dynamo for a circuit efficiency ratio of n % must with a lead resistance i and hot lamp resistance λ be equal to

$$\frac{\lambda}{100-n} - l = \frac{F\,A}{F+A},$$

or the multiple arc resistance of field and armature. As F, the field resistance, can be calculated as above, and λ is known, the necessary armature resistance A can be obtained. The construction of machines does not come within the scope of the present article, or we might trace this further.

(TO BE CONTINUED.)

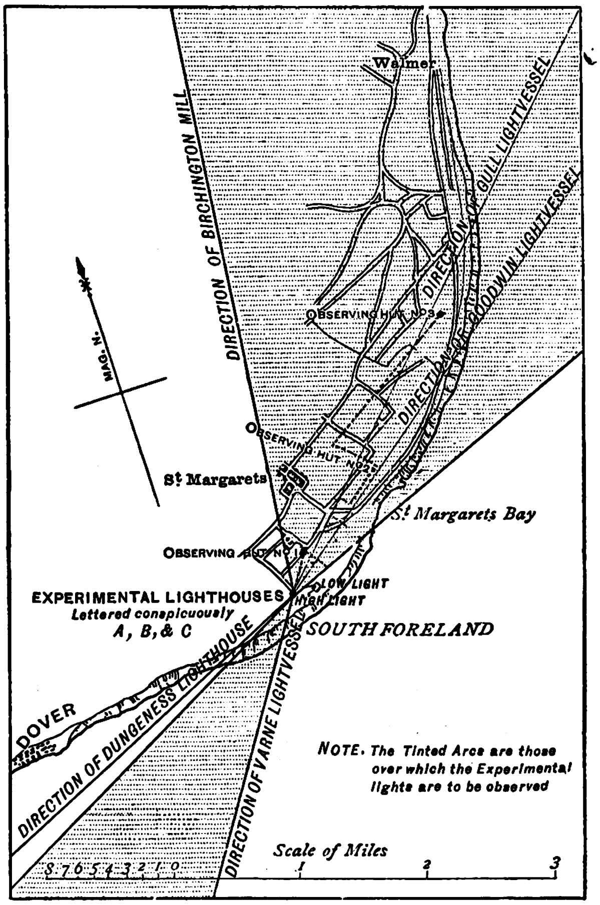
THE TRINITY HOUSE EXPERIMENTS ON LIGHTHOUSE ILLUMINANTS.*

The great advances made during the past few years in the science of illumination have rendered it desirable, or rather absolutely necessary, that experiments should be undertaken with a view to the determination of the advantages and disadvantages attending the use of different illuminants in lighthouses. With this view the Corporation of Trinity House have commenced a series of experiments at the South Foreland.

There are at present on the South Foreland two lighthouses, known as the high light and low light, and both of these are illuminated by electricity. Near these, three experimental lighthouses have been erected for use with the electric light, with gas, and with oil respectively. The electric apparatus consists of three arc lamps and three magneto-electric machines made by Baron de Meritens. The lamps are placed one above the other in the tower. The carbons being used are "compound carbons," made up of many small rods of carbon of square section, coated with copper, and Siemens's "core-carbons," made of gas carbon, with a central rod of graphite. When worked up to their full power, each lamp is estimated to be capable of giving a light equal to 30,000 candles.

The second tower is fitted up with Mr. Wigham's gas burners. To supply the burners a small gasworks, fitted with retorts, purifiers, and a gasholder capable of holding about 5,000 cubic feet, have been erected near by. The tower contains four burners, one above the other, each burner consisting of concentric rings of jets. The total number of jets on each burner is 108, making a total on the four burners of 432 jets; but the outer rings may be removed when less light is required, so that each burner may be used with 28, 48, 68, 88, or 108 jets. A talc chimney above the flame produces the necessary draught; no glass or talc is placed over the most luminous portion of the flame.

The intensity of the light when all the jets on all four burners are used is stated by the inventor to be equal to 12,000 candles. The third tower is for the present devoted to the oil and gas burners invented by Sir James Douglass. The oil is supplied from a tank to the burners under a slight pressure. One oil burner has six concentric wicks, and has a power of 720 candles; a second has seven wicks and a power of 1,000 candles. There are three burners in the tower, placed one above the other. Each tower is provided with lenses both for revolving and for fixed lights. The highest power of the gas tower is a quadriform light, of the other towers a triform light. Besides the illuminants already mentioned, there are gas burners from the Sugg and from the Siemens Companies, which will be tested in the lighthouse towers.



Plan showing points of observation for testing the power of the various lights being tried at the South Foreland.

For observing the lights and testing them, a line of observation has been measured out in the direction of Deal, and three huts have been erected at a distance of half a mile, a mile and a quarter, and two miles and a half respectively from the towers. These huts are fitted up as photometric observatories. The lights are focussed on one of the huts, and they are then measured in all conditions of weather by means of the pentane unit of light devised by Mr. Vernon Harcourt.

* Reprinted from *Nature*, for Aug. 14.

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When the weather is too thick to allow of direct comparison with the unit, the lights are compared one with another by means of a polariscope-photometer, in which the ordinary image of one light is brought to equality by means of a Nicol prism with the extraordinary image of another light. In ordinary weather a ray from the lighthouse tower enters a hole in a shutter and falls on a portion of a paper disc. A contiguous portion of the disc is illuminated by the pentane candle fixed on one side of the opening in the shutter. The disc can be moved on a trolley to and fro until equality of illumination is reached, when its distance from the candle is measured. This measure and the known distance of the observatory from the lighthouse give the necessary data for determining the illuminating power of the light. By these measurements, taken at different distances in various states of the atmosphere, the penetrative power of the several illuminants will be determined. For instance, in very clear weather the electric light may give twenty times the light of the oil light; a slight haze comes on and the electric light is found to be only ten times as bright. It has suffered in a greater ratio than the other. A mist blows by the towers, and the superiority of the electric light becomes less and less marked; before the lights are finally obscured the superiority has vanished. It need hardly be stated that this question of penetration is the most important point the Trinity House are called on to settle.

The principle of superposition of lights also raises an interesting point. When two lights are placed close together they can be seen at a greater distance than one light. Up to what point will this increase of range continue on multiplying the lights without altering the intrinsic brightness of each? It may be that in thick weather the eye can detect a large area of low illumination better than a smaller area of higher illumination; and it may be that the electric light with its smaller lenses suffers from this reason in comparison with the oil and gas lights with their larger lenses.

We hope that the experiments will not be discontinued before these points have been thoroughly sifted, as they only can be satisfactorily, on the actual working scale.

We may add that the electric machines and cables are being tested by Professor Grylls Adams, and the photometric observations taken by Mr. Harold Dixon. Mr. Vernon Harcourt is appointed to watch the experiments generally and report to the Board of Trade.

We give a plan of the district showing the point of observation, which includes the Coast Guard stations and light-ships in the vicinity.

LIGHTNING FLASHES.

We think the following letter and illustrations, taken from last week's *Colliery Guardian*, may be interesting to our readers. The writer is Mr. Ralph Loudon, of Framwellgate Colliery, Durham:—

"With your permission I should like to call the attention of the readers of your journal to, not a curious form of lightning, but a form seldom witnessed by persons in our latitudes.

"The accompanying diagrams, Nos. 1, 2, 3, represent fairly the appearance of three discharges of electricity which occurred on Sunday, the 13th ult. Fig. 1 appeared of a brilliant yellow colour, and hung for from three to five seconds like a ribbon dangling in the heavens. The discharge was direct, from cloud to earth, as may be seen from the appearance of the lightning presented.

"After an elapse of about a quarter of an hour a second discharge took place, and had the appearance as given in Fig. 2. The colour in this case was of a bluish yellow, and remained visible for about two seconds. The atmospheric resistance was probably stronger in the latter than that of the former; hence the path taken up by the lightning.

"Still later on in the evening another phenomenon was presented to vision. Fig. 3 is as near the leading features of the discharge as I remember. It was momentary flashes of pale lightnings, and seemed to emanate from a nucleus, but to give anything like an accurate outline of this discharge is quite beyond my power.

"Suffice it to say, the representation given shows how strangely Fig. 3 contrasts with Fig. 1. Rain was falling heavily during this thunderstorm. Similar appearances of lightning followed, but the clouds had drifted too far from my

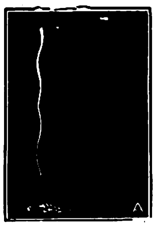

Fig. 1.

Fig. 2.

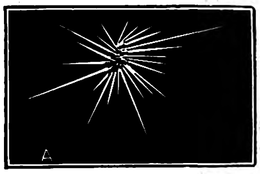

Fig. 3.

locality for me to map anything like good pictures. The reason I have troubled you thus is because these are the first phenomena of the kind I have seen, although some hundreds of times I have seen similar discharges from electrical machines. Books on electricity speak of discharges of electricity from the clouds like those given you as a common occurrence, but I wonder how many of your readers can compare these book illustrations to the discharges in nature. Hoping these illustrations may prove of service to many thoughtful minds, more especially those who take a lively interest in electrical matters, yours, &c."

EXPERIMENTS ON THE EFFICIENCY OF INCANDESCENT ELECTRIC LAMPS.*

BY HORACE B. GALE.

(CONCLUDED FROM PAGE 307.)

We have then to express the relations of three pairs of quantities. This might be done by three separate diagrams, but as the current is always equal to the electro motive force divided by the resistance, it may be represented, for any point on the curve, by the tangent of the angle included between the vertical axis of co-ordinates, and a line from the origin to the given point. Therefore, by drawing radial lines through the origin (which is in this case outside the limits of the diagram), we are enabled to lay off amperes of current on a scale of equal parts at the bottom, thus making the same curve express the relation between three variables.

To find the current for any point on either of the curves, it is necessary only to follow a radial line from the given point down to the scale at the base of the diagram; or, starting with a certain current, follow the radial lines up to the corresponding point on the proper curve; then to find the resistance of the lamp with the given current, follow a horizontal line from that point to the scale at the right; or to find the electromotive force follow a vertical line through the same point to the scale at the top. In short, given any one of the three quantities—electromotive force, current, or resistance—the other two may be found at once from a single curve. This device for expressing graphically the triple relation between the principal electrical quantities the writer believes to be new, and it is presented as one that will be frequently found convenient.

In other diagrams electromotive force is again represented on the horizontal scales at the top and bottom, and the height of any point on either curve shows on the vertical scales at

* Reprinted from *Van Nostrand's Engineering Magazine.*

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each side the number of candle-powers of light which the lamp will give with the indicated electromotive force. The resistance of a lamp is found to fall quite rapidly as the electromotive force is increased, until the carbon becomes incandescent, when the change goes on more slowly, the resistance of a lamp when giving its light being rather more than half its resistance when cold. The candle-power increases slowly at first, but afterwards with increasing rapidity, until, if the electromotive force is carried above a certain point, the carbon filament is broken. Other curves show clearly what has before been stated, *i.e.*, that a certain amount of power must be expended in a lamp before we begin to get any light; and that the brilliancy of the light expressed in candle-powers then rises more and more rapidly as the energy expended is increased; also how rapidly the efficiency of the lamps increases as the candle-power is raised.

It is noticeable that all the curves have the same characteristics, viz., that the efficiency at first rises very rapidly with increase of candle-power, and that afterwards, while the change goes on more and more slowly, the rate of increase in efficiency becomes at the same time more nearly uniform, or in other words, the curve approaches to a straight line. This would indicate that, however high the temperature of a carbon filament may be raised, raising it higher will still increase its efficiency as a light giver.

It must not be inferred, because the curve of any lamp is above the rest, that this lamp is absolutely more efficient than the others; for, as already pointed out, when a lamp designed to give 10 candle-power is run at, for example, 16 candle-power, its efficiency becomes higher than its normal value; whereas, if a 24-candle lamp is run at 16 candle-power, its efficiency falls below its normal value. Consequently, when lamps rated at different candle-powers are compared at the same candle-power, the lamp with the lower rating has an advantage. The only way to arrive at a fair comparison is to take the efficiency of each lamp at a point on its curve which corresponds to the rated candle-power. Comparing the lamps in this way, we find that the Maxim 16-candle lamp stands highest, and the Edison 10-candle lamp next.

It should be noticed that the Edison 16-candle lamps furnished for this test were not of the same grade as those in general use for isolated lighting. The latter may be run in parallel circuit with the 10-candle lamps, each giving its own proper candle-power; whereas the Edison 16-candle lamps on which these tests were made would give only about six candle-power on the same circuit with the 10-candle lamps, when the latter were at their normal brightness. The diagram shows that at the same electromotive force the 16-candle lamps gave only about two thirds as much light as the 10-candle lamps. This peculiarity was due to the high resistance of the 16 candle lamps, which, as will be seen from the table of resistances previously given, averaged about 291 ohms when cold. Measurements afterwards made by the writer upon ten 16-candle lamps, collected from various plants of the Edison Company throughout New England, showed the following results:—

RESISTANCE COLD.

Lamp No. 1	162	Ohms.
" " 2	176	"
" " 3	163	"
" " 4	186	"
" " 5	177	"
" " 6	175	"
" " 7	189	"
" " 8	186	"
" " 9	212	"
" " 10	197	"
Average resistance	182·3	ohms.

These lamps averaged 16 candle-power at 95 volts, the same electromotive force required to bring the 10-candle lamps to their normal brightness, and were therefore evidently the grade of lamps intended to run on the same circuit with the latter. They were not obtained in time to make a complete test at all candle-powers, but measurements were made at the rated candle-power, which gave the following average results.

EDISON LAMPS AT 16 CANDLE-POWER.

Electromotive force	95·	volts.
Current strength	0·92	ampere.
Resistance	103·3	ohms.
Volt-amperes	87·4	
Candle lights per horse-power	136·6	
Lamps per horse-power	8·54	

The following are the figures for the Maxim 16-candle lamps:—

MAXIM LAMPS AT 16 CANDLE-POWER.

Electromotive force	68·9	volts.
Current strength	0·9	ampere.
Resistance	76·5	ohms.
Volt-amperes	62·2	
Candle lights per horse-power	192·	
Lamps per horse-power	12·	

The results of these experiments indicate that the essential factor in the efficiency of an incandescent lamp is not high resistance, but high incandescence. The Maxim lamps, which displayed the highest efficiency, gave a slightly whiter light than the others, showing that the carbons were heated to a higher temperature, though their resistance was lower than that of the Edison lamps. The fact that a low resistance filament is usually coarser than one of high resistance would tend to make it endure equally well at a higher temperature.

DYNAMO-ELECTRIC GENERATORS.

(CONTINUED FROM PAGE 324.)

Arago Disc.

We now come to a machine of more recent invention than the others or most of them, and one which presents some novel and interesting features. Instead of using two field poles, widely removed, and with a mass of iron between them to concentrate the field, there is a large number of magnets of much smaller size, they are brought very nearly together, and no iron whatever is used in the armature. To accomplish this the field-magnets are arranged in two sets, with their axes parallel to the spindle of the armature, and distributed in a circle at equal distances apart. These two sets, say with ten magnets in each, are placed opposite each other, the inner ends with expanded pole-pieces being free, and the outer ends bolted to, and held in position by, two upright ring-standards. The coils are connected so as to form alternate poles in each set, unlike poles in each set facing each other. On passage of a current there are formed twenty alternating electro-magnets, with strong fields between opposite poles, and, because of the proximity of these poles, the concentration is effected without introducing any iron mass between. If any radial wire be rotated between these poles, it will, in one revolution, pass through ten strong fields, cutting the lines of force at right angles, and having induced currents generated which will change direction ten times. To obtain this radial direction of the moving wire, the coils are wound on a block in a triangular fashion, small curved blocks of insulating material being introduced for clamping screws. The centre block is then removed, leaving a firm, hollow, triangular coil, the making of which, being on a form and in a lathe, has occupied little time and labour. A number of these coils are now built up into a disc armature, and are held in position by a hub plate and a ring of composition, and screws passing through the insulating blocks. If to be an alternating machine separately excited, then there are as many coils as there are pairs of field-magnets; but if for continuous currents two more are used, that is twelve when there are ten pairs of field-magnets. In the alternating machine the coils are connected, so that whatever the current it has the same circuit direction for all coils, and the two free ends of the range of coils are taken to two rings, from which the current is taken by brushes or springs. With ten coils there are ten reversals of the current in a revolution. When, however, the current is to be continuous the connections to the commutator are much more complicated than is ordinarily the case.

The coils are connected in reverse order in a continuous circuit, and the bights of the connections connected to the

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rings by wires, &c. Considering a single coil, in one-half a revolution it must have the current reversed in it five times, because it passes through five alternating fields. Since there is not the same number of armature coils as there are poles, the reversal of current in the different poles will not be simultaneous, but will occur in two coils, and opposite ones only at the same time; but the total number of reversals in a half revolution must be thirty—that is, the number of pairs of coils in the armature multiplied by the number of pairs of field-magnets passed in that half revolution. In other words, the successive reversals follow each other six times as fast as the reversal in a single pair, the armature advancing one-sixtieth part of a full revolution between two successive reversals. But the commutator advances no faster than the armature, and if there were only twelve blocks, the potential of a single block would change five times while in contact with one brush. Hence, it becomes necessary to multiply the number of commutator strips, so that strips of like potential may be continually presented to the proper brushes.

A little consideration will show that if the number of armature coils is m and the number of pairs of field coils is l, the number of sections in the commutator must be $\frac{ml}{2}$ in the case taken, 60—and that each bight or ring must be connected with $\frac{l}{2}$ section of the commutator, at regular intervals, and in sequence. In the machine exhibited at the Crystal Palace flat contacts were used, causing a great deal of sparking, but the machine is a new one, and some practice is necessary in developing its unquestionably valuable principles. If, as is probable, the sparking of the machine can be stopped, it will prove a highly effective dynamo, because there is no waste of energy in heating iron, and the machine can be cheaply made. The brushes are mounted on a swinging frame. Several forms are made; among others being one with a double armature and commutator, the one supplying the field with a continuous current, and the other the external circuits with an alternating current. Another form has only two pairs of field-magnets, and with radially wound armature coil.

Siemens Alternating.

This machine, like the one just described, has a large number of field-magnets. From a base-plate two circular frames rise, which are steadied by tie-bars extending from one side to the other. On the inner faces project a range of circular magnets with extended pole-pieces, the cores being turned down at the outer end so as to fit into holes in the circular frames, where they are firmly held by nuts. They are so wound that each magnet has opposite to, and on each side of it, poles of the opposite character. The armature coils are arranged in disc form, and there are as many as there are field-magnets. The coils are wound on an oval or elliptical piece of wood, the longest diameter being radial. They are mounted in a German silver frame, which is thickly pierced with holes to cut off the induced currents which would be formed. The coils are connected in any desired arrangement of series or multiple circuit, or in independent circuits, the ends being taken to rings on the spindle of the armature, whence the currents are taken off by contact springs. The field is excited by a separate circuit from another machine. A common arrangement is to have a high speed engine, a continuous current dynamo, and an alternating current machine mounted on one common bed-plate.

Lontin.

I will briefly describe two forms only, both of which depend for the production of currents upon the magnetisation and demagnetisation of circular or conical cores which are surrounded by wire. In one of these the field-magnets are short and vertical. On a central boss are arranged forty soft iron spokes, in four circles, each set being one-fortieth of a revolution in advance of the next on one side, thus constituting a helical construction. The object of this is to equalise the effort on the armature, and produce a more equable current. Since a magnet coil has the same current induced in it when leaving a pole of given character as when approaching the opposite pole, it follows that all the wire above the horizontal line joining the poles of the field-magnet has a current induced in one direction, and the wire below it a current in the opposite direction. By connecting all the coils in a series, and bringing the several bights to a range of commutator strips, a continuous current is obtained.

This current is generally used to excite another machine, one used for distributing currents over several circuits. In this the inducing or field-magnets are ranged around the periphery of a drum, which is rotated, the current being supplied through contact springs to maintain the spokes at a constant alternate magnetic state. Around this ring, enclosing the periphery, is a fixed iron shell, from the inner surface of which radiate a large number of short soft iron cores, wound with wire. These are coupled in independent sets, and the ends are taken to a switchboard. When the drum rotates the shell poles are alternately magnetised and demagnetised very rapidly, and alternate currents are formed which are distributed over the different circuits. This total reversal of the polarity of the cores is an objection of considerable weight, and is one reason why these machines are not as efficient as those of the Gramme and Siemens type.

Gramme Auto-Exciting.

This is a small machine designed to furnish an alternating current, and, at the same time, to be self-exciting. On a cast-iron bed-plate are bolted two upright and nearly circular standards, connected together by six tie-rods. One of these has a circular rib or lip, on the inside of which are fastened four magnets, joined two by two, so as to form two poles only. On this end of the shaft is carried a small Gramme ring and commutator, and the current formed supplies both fields. On the other end of the spindle are carried the inducing magnets, a range of six, radially mounted, and with extended pole-faces. These faces are curved, so as to present an equal magnetic action for some distance. The coils in which the currents are induced are arranged in the form of a cylinder, and enclose the inducing magnets, the inner turns being in close proximity to the polar extensions. The ends are taken to a switchboard, where they may be coupled for tension or quantity. The machine is compact, but, save the fact that it is much used with the Jablochkoff lights, I know nothing of its efficiency.

SHIPS' LIGHTS.

We give below the latest regulations regarding ships' lights which have been drawn up by the Board of Trade and the Admiralty jointly, and have received royal sanction. We think they will prove interesting to those of our readers engaged in cable-laying operations, and although they refer in part only to a cable ship, still those on board the latter should be acquainted with the whole of them. The preface to the regulations tells us that on and after September 1st, 1884, the new regulations shall, so far as regards British ships and boats, be substituted for the regulations dated the 14th August, 1879.

Regulations for Preventing Collisions at Sea.

Art. 1. In the following rules every steam ship which is under sail and not under steam is to be considered a sailing ship; and every steam ship which is under steam, whether under sail or not, is to be considered a ship under steam.

Rules concerning Lights.

Art. 2. The lights mentioned in the following articles, numbered 3, 4, 5, 6, 7, 8, 9, 10, and 11, and no others, shall be carried in all weathers, from sunset to sunrise.

Art. 3. A seagoing steamship when under way shall carry—

(*a*) On or in front of the foremast, at a height above the hull of not less than 20ft., and if the breadth of the ship exceeds 20ft., then at a height above the hull not less than such breadth, a bright white light, so constructed as to show an uniform and unbroken light over an arc of the horizon of 20 points of the compass, so fixed as to throw the light 10 points on each side of the ship, viz., from right ahead to two points abaft the beam on either side, and of such a character as to be

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visible on a dark night, with a clear atmosphere, at a distance of at least five miles.

(b) On the starboard side a green light, so constructed as to show an uniform and unbroken light over an arc of the horizon of 10 points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the starboard side, and of such a character as to be visible on a dark night, with a clear atmosphere, at a distance of at least two miles.

(c) On the port side a red light, so constructed as to show an uniform and unbroken light over an arc of the horizon of 10 points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the port side, and of such a character as to be visible on a dark night, with a clear atmosphere, at a distance of at least two miles.

(d) The said green and red side lights shall be fitted with inboard screens projecting at least 3ft. forward from the light, so as to prevent these lights from being seen across the bow.

Art. 4. A steam ship, when towing another ship, shall, in addition to her side lights, carry two bright white lights in a vertical line one over the other, not less than 3ft. apart, so as to distinguish her from other steam ships. Each of these lights shall be of the same construction and character, and shall be carried in the same position as the white light which other steam ships are required to carry.

Art. 5 (a) A ship, whether a steam ship or a sailing ship, which from any accident is not under command, shall at night carry, in the same position as the white light which steam ships are required to carry, and, if a steam ship, in place of that light, three red lights in globular lanterns, each not less than 10in. in diameter, in a vertical line one over the other, not less than 3ft. apart, and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles; and shall by day carry in a vertical line one over the other, not less than 3ft. apart, in front of, but not lower than her foremast head, three black balls or shapes, each 2ft. in diameter.

(b) A ship, whether a steam ship or a sailing ship employed in laying or in picking up a telegraph cable, shall at night carry in the same position as the white light which steam ships are required to carry, and, if a steam ship, in place of that light, three lights in globular lanterns each not less than 10in. in diameter, in a vertical line over one another, not less than 6ft. apart; the highest and lowest of these lights shall be red, and the middle light shall be white, and they shall be of such a character that the red lights shall be visible at the same distance as the white light. By day she shall carry in a vertical line one over the other not less than 6ft. apart, in front of but not lower than her foremast head, three shapes not less than 2ft. in diameter, of which the top and bottom shall be globular in shape and red in colour, and the middle one diamond in shape and white.

(c) The ships referred to in this Article, when not making any way through the water, shall not carry the side lights, but when making way shall carry them.

(d) The lights and shapes required to be shown by this Article are to be taken by other ships as signals that the ship showing them is not under command, and cannot therefore get out of the way. The signals to be made by ships in distress and requiring assistance are contained in Article 27.

Art. 6. A sailing ship under way, or being towed, shall carry the same lights as are provided by Article 3 for a steam ship under way, with the exception of the white light, which she shall never carry.

Art. 7. Whenever, as in the case of small vessels during bad weather, the green and red side lights cannot be fixed, these lights shall be kept on deck, on their respective sides of the vessel, ready for use; and shall, on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such manner as to make them most visible, and so that the green light shall not be seen on the port side nor the red light on the starboard side.

To make the use of these portable lights more certain and easy, the lanterns containing them shall each be painted outside with the colour of the light they respectively contain, and shall be provided with proper screens.

Art. 8. A ship, whether a steam ship or a sailing ship, when at anchor, shall carry, where it can best be seen, but at a height not exceeding 20ft. above the hull, a white light, in a globular lantern of not less than 8in. in diameter, and so constructed as to show a clear, uniform and unbroken light visible all round the horizon, at a distance of at least one mile.

Art. 9. A pilot vessel, when engaged on her station on pilotage duty, shall not carry the lights required for other vessels, but shall carry a white light at the masthead, visible all round the horizon, and shall also exhibit a flare-up light or flare-up lights at short intervals, which shall never exceed fifteen minutes.

A pilot vessel, when not engaged on her station on pilotage duty, shall carry lights similar to those of other ships.

Art. 10. Open boats and fishing vessels of less than 20 tons net registered tonnage, when under way and when not having their nets, trawls, dredges, or lines in the water, shall not be obliged to carry the coloured side lights; but every such boat and vessel shall in lieu thereof have ready at hand a lantern with a green glass on the one side, and a red glass on the other side, and on approaching to or being approached by another vessel such lantern shall be exhibited in sufficient time to prevent collision, so that the green light shall not be seen on the port side nor the red light on the starboard side.

Art. 11. A ship which is being overtaken by another shall show from her stern to such last-mentioned ship a white light or a flare-up light.

[We omit articles 12 to 26.]

Art. 27. When a ship is in distress and requires assistance from other ships or from the shore, the following shall be the signals to be used or displayed by her, either together or separately, that is to say:

In the daytime—

1. A gun fired at intervals of about a minute;
2. The International Code signal of distress indicated by N C;
3. The distant signal, consisting of a square flag, having either above or below it a ball, or anything resembling a ball.

At night—

1. A gun fired at intervals of about a minute;
2. Flames on the ship (as from a burning tar barrel, oil barrel, &c.);
3. Rockets or shells, throwing stars of any colour or description, fired one at a time, at short intervals.

ELECTRIC LIGHTING AT GREENOCK.

It will be remembered that some time since the Greenock Police Board authorised the expenditure of £1,000 in electric lighting experiments, the motive power to be supplied by turbines. At the last meeting of the Board, held a few days ago, the following report by Mr. Stewart, gas manager to the Board, was read:—

"I have to report that seven offers for the supply of electric lighting plant have been received, as follow:—R. E. Crompton and Co., £1,050; E. Beckingsale, £1,040; Maxim-Weston Company (per H. Watt), £1,065 10s.; Muir and Mavor, £943; Anglo-American Brush Electric Light Company, £1,186 11s. 8d.; Henry Bennett and Co., £1,000; J. D. Andrews and Co., £900. With respect to offer No. 1, no details of estimate are given or any explanations. Offerer No. 2 gives long explanatory letter containing a good deal of information, and detailed offer, and also alternative tender for apparatus without the wire. Offerer No. 3—This is for arc lamps only, and two dynamos only, and offer is otherwise not consistent with specification. Letter giving explanation is with offer. Offerer No. 4 is in terms of specification. Offerer No. 5 includes wood trough and other apparatus not in the specification, amounting in all to £275, which deducted from amount of offer £1,186, leaves £911 11s. 8d. as nett amount of offer for comparison. This offer also includes the using of Callenders' bitumen coated wire, which is preferred, I am told, to the Kinetic Company's double lead coated wire. Offer No. 6 is a lump sum without details except a general statement in letter. Offer No. 7 is also a lump sum, and includes cost of laying wires in wooden trough of their own pattern. Messrs. Siemens and Co. declined to offer, and Messrs. the Callenders' Bitumen Telegraph Company have included their offer with the Anglo-American Brush Company, and send letter explaining why their wire is preferred over the Kinetic Company's wire." The Electric Lighting Committee agreed that Mr. Stewart and Mr. Wilson, C.E.,

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should be authorised to consult Professor Jamieson, Glasgow, regarding the sufficiency of the specification and offers, and report to a future meeting, and the Board agreed to leave the matter in the committee's hands." The clerk was authorised to give the statutory notice to the Postmaster-General prescribed by the Electric Lighting Provisional Order.

THUNDERSTORMS.

A very ably-written account of the thunderstorms which broke over Scotland between Saturday and Tuesday, the 9th and 12th instant, appeared in *The Scotsman* of Wednesday week, for which we could not find room in our last issue. We reproduce a portion of it this week. Our contemporary says :—

"A thunderstorm of almost unsurpassed severity broke over the south-east of Scotland yesterday (Tuesday, the 12th instant). Alike in point of duration and intensity, there has been nothing experienced in Scotland to compare with it since, at all events, the great storm of July, 1873 ; and in some respects the storm of yesterday proved more violent and destructive than any within the recollection of old people. It broke over Edinburgh at about half-past nine in the morning, it attained its greatest violence about noon, and it continued to rage till almost 4 o'clock in the afternoon. The area of the disturbance seems to have been as extensive as its effect was alarming and disastrous. As regards the City of Edinburgh, the storm of eleven years ago may have been as fierce. But on few former occasions within memory has the flooding been more extensive, and if on former occasions the effect of lightning may have been productive of more actual damage, seldom has it been more alarming or threatening. The singular brightness and frequency of the lightning flashes, the terrific roar of the thunder which raged for hours immediately over the city, the remarkable spell of darkness into which the city for a considerable time was plunged, the great showers of rain and hail, the wonderful phenomena which almost everywhere were witnessed, particularly in localities where buildings were struck with the lightning, the narrow escape of properties from fire, and the numerous casualties render the storm perhaps the most memorable during recent years.

"Thunderstorms of more or less severity may be said to have prevailed throughout the greater part of Scotland since Saturday morning. A sharp outbreak was experienced on the shores of the Firth of Forth early on Saturday. About three on Monday morning a storm of short duration broke over Edinburgh, and in the afternoon again there were frequent flashes of lightning and peals of thunder. Monday was also characterised by a remarkably high temperature ; at eight in the evening the reading of the thermometer ranged from 85deg. in London to 58deg. in the Shetlands.

"As already indicated, Edinburgh has witnessed nothing to compare in intensity with the storm of yesterday (Tuesday, the 12th) since a day which is well within the recollection of observers—the 22nd of July, 1873. Like that of yesterday, the storm of 1873 was preceded by an unusually high temperature, the thermometer having on that occasion risen to 90deg. in several places in the Lothians. Three well-defined periods of intensity were noted during the storm of yesterday. The first continued from the outbreak till 11:30 ; there was then a lull, during which occurred some remarkable phenomena, notably the darkness in which the city was plunged ; the second period of intensity continued from noon till after one ; and the third from half-past one. The storm had passed to the north and north west by three o'clock ; but up till four there were now and again very loud peals of thunder. While the storm was at its height the frequency of the lightning flashes was such as to fairly dazzle the eyes of the spectator, and to create much alarm in many quarters of the city. During the storm of 1873 one of the observers of the Scottish Meteorological Society counted in one hour 680 flashes, with their accompanying thunder claps. This gives a rate of fully eleven per minute. The results of such exact observation yesterday may indicate an equally if not a more severe disturbance. On several occasions, particularly between twelve and one o'clock, the lightning was so persistent, flash succeeding flash in such quick succession, that it was almost impossible to determine numbers, or the thunder report which accompanied a particular flash. One observer says that during a considerable period flash must have followed flash at the rate of nine or ten a minute, and from ten to twenty minutes past twelve there were brief periods of continuity of light which were frequent as remarkable. The effect of the lightning flashes amid the strange gloom that prevailed was singularly impressive. Just about noon the lightning conductor at St. Giles's was three times struck. The lightning on each occasion appeared, after coming into contact with the conductor at the top, to quiver round the rod, to rush down and to burst out into a beautiful sheet of light just above the roof. It ascended, and again descending, burst out afresh and disappeared. In other quarters of the city the effect of the lightning was watched with much interest. Correspondents send notes of phenomena witnessed while the storm was at its height. 'A gentleman,' writes one, 'was proceeding along Easter-road about eleven o'clock, when suddenly he observed dropping from the clouds an immense ball of fire. On nearing the ground it burst with a terrific crash, leaving behind it a cloud of smoke, which hung for some time in the air, and gradually dispersed. The sight was a most impressive one, and likely to be remembered by all who may have have seen it.' Equally striking sights are described by another :—'While watching to-day's thunderstorm, I was much interested in seeing, a little north of the zenith, a complete ring of broken clouds wheeling round and round as if in a whirlwind, while the rest of the expanse of cloud remained still and unbroken. Another curious phenomenon I noticed. At the height of the storm a fiery "pair of scales" seemed for an instant suspended between the heavens and earth.' The wind had been—the little there was of it—from the north-north-west. Afterwards it changed to east-north-east. At nine in the morning the barometer, reduced to 32deg. and sea level, read 29·890 inches. At 11:50 it had risen to 29·900—the higher reading thus occurring at the termination of the period of the greatest darkness. Immediately thereafter the barometer began to fall steadily till four in the afternoon. This apparently slight rise in the barometer from nine till noon, and the more rapid, though still slight fall from noon till four in the afternoon, are, it has been observed, features peculiarly characteristic of thunderstorms, and deserve observation and examination. About ten the rain was exceedingly heavy, and it continued so during more than an hour. During the period of darkness, and twenty minutes thereafter, there was little or no rain ; but from about noon till almost two, the rainpour and hail showers were singularly severe. The hail may be said to have been little pieces of clear ice, measuring as much as half an inch in diameter. An observer near the Calton Hill says that pieces of this size were not falling here and there ; there were showers of them. The hail fell with, or immediately after, the heaviest downpour of rain.

"The weather moderated immediately after four, and there was a long period of calm. But about nine o'clock last night there was a renewed disturbance. Lightning flashed at intervals across the sky, and about half-past ten there were several peals of thunder. The following readings of the barometer, corrected and reduced to 32 degrees and sea level were taken at Leith by Messrs. Bolam and Redpath, of the Government Navigation School :—5:45 a.m., 29·899 ; 7:0 a.m., 29·890 ; 8:15 a.m., 29·896 ; 6:45 p.m., 29·888 ; 7:45 p.m., 29·888 ; 8:45 p.m., 29·884 ; 10:30 p.m., 29·861. During the day the barometer was very unsteady, but at half-past ten last night was falling steadily. At half-past one this morning there was a good deal of lightning, but no thunder. The temperature was high, and a heavy haze hung over the city.

"The rainfall at Leith between ten and four o'clock yesterday was 1·62 inch, which is equal to 162 tons per acre."

We cannot find room for the long record of accidents from lightning strokes given by the *Scotsman*, but we may mention that two of a group of four telephone wires supported on the roof of a farmhouse at Quarryholes, Easter-road, were destroyed by the lightning. A correspondent who witnessed the occurrence writes :—"There is a stretch of 150 yards from the telegraph pole on the south to the roof of the farm buildings, and the two wires between these points were totally demolished, the electric fluid escaping at joinings in the wires (covered with copper wire and strong cord) near the supports on the roof, with a loud report, amid a shower of sparks, flame, and sulphurous smoke. Several of us were standing near, and it appeared as if one of the "Sultan's" 10in. shells had burst over our heads. The wires were reduced into sparks, which fell about us in a molten state. I have picked up a handful of these, varying in length from 1-16th of an inch to 1½in., the metal being fused and the substance burned out of it. The fluid luckily confined itself to the wires." Another case in which the lightning is supposed to have entered a building by way of a telephone wire is recorded from Broughty Ferry. Our contemporary says :—"A young man, Mr. John Bremner, residing in West Brook-street, was struck by the electric fluid, and has never regained consciousness. Being an invalid, he had a private telephone connected with the church, and the electricity is supposed to have travelled along the wires and entered the room where he was sitting." He is since reported to be recovering, though complaining of acute pains in his back and chest. A peculiar case is reported from Port Glasgow where several men engaged on a steel ship, being built in the yard of Messrs. Russell and Co., Ardgowan-street, were struck by lightning. One of them, John Bolton, foreman carpenter, "had the skin of his mouth completely peeled off down to his throat." Another, M'Millan, a labourer, "was struck on the back, the lightning leaving a mark the size of a man's hand in the form of a tree."

Messrs. John Davis and Sons, of All Saints' Works, Derby, write that, during the thunderstorm on the 9th inst., a housemaid named Emma Harveson, whilst in the act of cutting bread for tea, at "The Limes," Mickleover, and when in the act of putting the knife into the butter (the window being open), had the knife violently struck out of her hand by a flash of lightning and dashed on the ground, the blade being broken in two pieces. It is presumed that the ivory handle, being a non-conductor, saved her from injury. There were two other knives on the table, but they were not influenced. About 45in. from the window were *two newly painted* iron rain down spouts. These show no signs of influence. The knife was broken whilst in her hand and the butter thrown about in all directions. Messrs. Davis and Sons state that the knife is in their possession, but bears no evidence of fusion by lightning.

LEGAL.

Re the Gulcher Electric Light and Power Company.

MR. CROSSKEY applied on the 20th inst. before the vacation judge, Mr. Justice Wills, for the sanction of the Court to the reduction of the capital of the above Company from £300,000 in £5 shares to £150,000 in like shares. The matter had in the usual manner been referred to the chief clerk, who had found that some creditors, but not all, consented, to the proposed reduction of capital. It now appeared that all the creditors who had not consented before the chief clerk had since either consented or been paid, with the exception of one creditor for £15 8s. 2d., whose debt it was now proposed to pay into court.

His LORDSHIP sanctioned the proposed reduction, and dispensed with the title "and reduced" from the expiration of fourteen days after the date of the order.

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COMPANIES' MEETINGS.

The River Plate Telephone and Electric Light Company (Limited).

The second ordinary general meeting of this Company was held on Monday at the Cannon-street Hotel, Colonel Gouraud in the chair.

The report of the directors having been taken as read,

The CHAIRMAN said: I should first, perhaps, make one remark with regard to this meeting. The meeting was originally called almost immediately after the annual accounts of the Company were made up to the end of the Company's year—the 31st January last—when, as you were informed by a subsequent notice, a question had been raised as to the powers of the directors acting for the Consolidated Company with respect to the settlement of the debt to that company by this Company. The consequence of that was that the settlement in question had to receive the consideration of the shareholders of the Consolidated Company. That involved all the delay that has since occurred. The meeting of the Consolidated Company was in due course held, and the settlement unanimously approved by the shareholders of that Company. Immediately thereupon you were notified that your general meeting would be held with reference to the report, and with reference also to the ratification by yourselves of that settlement. But for the necessity of delaying this meeting you would have received your dividend some months ago, the money being at the time ready for distribution. So much with reference to the delay which you have experienced in receiving your dividend, and in meeting together for the purpose of receiving the report. With reference to the report I have really very little to volunteer to you. I think that you cannot but unanimously feel that it presents a very admirable position of the Company, more especially taking in connection with it the special resolution, and assuming that it will receive your support. The report tells you that the debt due to the Consolidated Company has since its date been settled, and it now remains with you to approve the correctness of the report, and if there are any questions I shall be pleased to answer them. You have a very handsome balance to carry forward, after paying the 9 per cent. dividend, which with the dividend paid last year will make a 9 per cent. cumulative dividend upon your investment from the date you made it. It is only in the power of the directors to recommend the dividend, but as soon as you approve it it will be paid.

Mr. CLARK: Is the dividend up to Christmas last?

The CHAIRMAN: Up to the end of January—up to the end of the Company's fiscal year. The Company's year terminates on the 31st January.

Mr. CLARK: Because the next year's termination will shortly take place.

The CHAIRMAN: That will be dealt with in next year's accounts.

Mr. CLARK: It is very late in the season for a Christmas dividend.

The CHAIRMAN: Well, I thought I had made a complete explanation for the reasons of the delay. It was impossible to have the meeting earlier.

Mr. CLARK: I think the matter ought to have been seen into before the notice was issued stating that everything was in readiness, and then it turned out that there was something amiss. I think the directors ought to have known all about that before they sent out the first notice.

The CHAIRMAN: I quite see your point, and can make it perfectly clear in a few words. You misunderstood one important point evidently. There was no question in this Company whatever. There was no doubt as to the powers of the directors of this Company to do all that they have done. They made up the report as soon as they got the accounts. The business is 6,000 miles from London. In due course the accounts came in and were audited, and the meeting was called. The doubt to which you refer, and which I thought I had explained, arose in the minds of some of the shareholders of the Consolidated Company as to the power of their Board to accept the settlement which the directors of that company and of this Company had agreed to; therefore it was proposed naturally to shield the directors from taking undue responsibility, although they believed—and believe now—that it was fully within their powers, and consequently a meeting of the Consolidated shareholders was called to consider the question. I presume that makes it clear to you.

Mr. CLARK: I think the directors should have made themselves thoroughly acquainted with that before they issued the first notice. I do not think that you have answered my question. I ask for information.

The CHAIRMAN: I have no doubt it is my own fault, I will not say it is yours.

Mr. CLARK: The directors knew there was a debt.

The CHAIRMAN: At the date of this report this Company had a creditor to a very large amount, and this creditor had been a creditor for a very long time, and it was considered desirable by the Boards of the respective companies—the debtor company and the creditor company—that the debt should be liquidated. Had no question arisen on the part of the other company to whom we owed this money we would have had our meeting at once and declared the dividend, but the question did arise in the other company as to the powers of the directors of that company to make the settlement. It was thought to be a settlement too much in favour of this Company, that was the reason given, and it is not unreasonable to expect that that might have been the case. The Directors of the Company were notified by a formal protest on the part of a number of their shareholders that they were not to carry out the settlement. Well, that raised the question of the powers of the directors, and in such cases it it invariably the custom that directors do not choose to go utterly regardless of consequences, but submit the matter to their shareholders for approval. That was done, and it has taken all this time. I will now move "That the report of the Company's working for the year ended the 31st of January last, with the balance-sheet, be adopted."

Mr. PATRICK CARNEGY: I beg to second that.

Mr. ATKINSON said that he bought some shares in what he considered to be the River Plate Telephone and Electric Light Company (Limited), and he was not aware that there were any debts owing. He knew nothing of any other company.

The CHAIRMAN replied that it was quite possible in buying shares in any company the hon. shareholder might not know at the moment what the debts were or what debts were owing to the Company. They had a progressive business, and it was not unusual for companies with that kind of business to borrow money. In the previous report, which was printed and circulated amongst all the shareholders, it was printed and published that there was a large debt owing by the Company, and that had proved to have been a debt very wisely incurred by the Board. It had been the means by which this Company had attained what he thought he was justified in saying was a most extraordinary position of success. The necessity of the Company to receive this credit, or to receive this assistance in the form of goods of one sort and other, arose from the fact that the shares were not taken up to an amount sufficient to meet the natural development of the business of the Company; therefore their being able to borrow was a fortunate circumstance, and it had worked to their advantage. The debt had now been settled on very satisfactory terms to the Company, and the assent of the shareholders would be asked to the arrangement.

The motion for the adoption of the report was then put, and carried unanimously.

The CHAIRMAN: In the report you have just adopted you have given your sanction to the payment of a further dividend, and I am going to ask you also, on the suggestion of the solicitor, to sanction the interim dividend which we paid you, which interim dividend was 9 per cent. per annum upon your entire investment up to the 30th April, 1883. The resolution is "That a dividend at the rate of 9 per cent. from the respective dates of payment to the end of January, 1884, including the interim dividend paid on the 1st August, 1883, be declared."

Mr. FITZGERALD: Excuse me, I should like to make a remark. It appears to me, with a debt of £20,000 owing to the Consolidated Company, which it was at that date, that that dividend should never have been paid. Of course, it has been paid to the shareholders, but, as a matter of policy, it should not have been declared as long as that debt was unsettled with the Consolidated Company. It seems to me—I do not know whether I am correct—that if the Company owes a large sum of money to another company, and that company could claim the money, the dividend should never have been declared by the company owing the money. I do not question that it was fairly earned, but it should have been explained to the shareholders that they owed the Consolidated Company at that date something like £20,000. I should like to make one or two further remarks in regard to this. I see that Colonel Gouraud states that when he accepted the chairmanship of the Company that the returns of the subscribers in Buenos Ayres and Monte Video showed a number of 1,160, and an annual value of £19,558. The increase up to the latest return shows 1,709 subscribers and an annual value of £26,985. Surely Colonel Gouraud does not take credit for having got those subscribers. The credit is due to the Board in Buenos Ayres. I think they are the gentlemen who are working there for us. I am merely making these remarks because I think it is not quite fair that the Chairman of the Company should take credit for things that have been done by other people. That is my way of looking at it. You know, gentlemen, all about the indebtedness of the Company. The Consolidated Company, of which I am at present the chairman, gave, or rather sold you instruments for the erection of installations in Buenos Ayres, but this Company could not pay the money, and that is the reason that this settlement has come about, and we, the present Board of the Consolidated Company, accept these debentures and shares in payment instead of cash for the instruments we have supplied. Of course we had to go into the books of the Company to see that everything was correct, and that is one of the reasons why your dividend was delayed. I merely mention that in case you should think I have in any way delayed the dividend. I assure you I should have paid the dividend myself if I could have done so on the date in May last, but until we saw everything was correct, as a matter of course we could not. I must endorse all Colonel Gouraud has said as to the position of the Company and the report as far as I can judge. The Company is doing extraordinarily well, and the dividend has certainly been earned. Of course some of you, gentlemen, are possibly aware of the reasons why the gentlemen do not offer themselves for re-election. It is hardly worth while that I should go into that, because the people who have been put in power in the Consolidated Company have determined to make this alteration on the Board.

The CHAIRMAN said that the remarks of Mr. Fitzgerald were premature, because the resolution had not been seconded, but he did not wish to interrupt that gentleman, but wanted to show him the patience which he (the Chairman) had displayed on many previous occasions.

Sir ALEXANDER ARMSTRONG then seconded the motion.

The CHAIRMAN: Gentlemen, with regard to Mr. Fitzgerald's remarks, I think I should be paying a very poor compliment to your intelligence if I were to point out to you that he rose to criticise the payment of the dividend in the same breath he told you we ought not to have paid it, and we had no right to do so in the face of the fact that we owed all this money, which the shareholders when they received this interim dividend did not know of. In the same breath he told you, by way of showing his importance as the Chairman of the Consolidated Company, and your supporter here, that if he had been able to do so he would have paid this dividend, which you are only receiving now, in May last. I think any further comment upon that is unnecessary, except in regard to the interim dividend being paid when the shareholders did not know that we owed the money. The interim dividend was paid almost immediately

after the report which was in the hands of all of you. I might mention to you, what perhaps you ought to know as something that took place at the meeting, that as the Directors then showed a large balance and handsome dividend in the report at the last annual meeting, a shareholder took very strong grounds that the Directors ought to pay a dividend, and he pointed out it was a most usual thing for Boards earning large dividends to pay the dividends, even if they borrowed the money, a fact to which we all assented, but which we did not think desirable to do at that time. So much then with regard to the dividend. I am glad to hear that Mr. Fitzgerald recommends the payment of the dividend, because if he took a contrary view in regard to that, I am sorry to be obliged to tell you you would not be able to have your dividend, as it would be in the power of an individual to keep you out of it. This leads me to make a reference to the portion of his remarks which applied to myself. It must be evident to you that Mr. Fitzgerald went a long way out of his way to make an insinuation; but that did not surprise me, because Mr. Fitzgerald has an unhappy weakness of doing that sort of thing. Mr. Fitzgerald, in another place, where he had certainly the advantage of me from the fact that he took the chair, claimed the credit—he evidently thought it a credit—for a production which I will venture to say is without any parallel in the history of companies in London—one full of insinuations unconnected with a single direct charge against any gentleman concerning whom the insinuations were made. It may be that that is Mr. Fitzgerald's idea of what is the duty of a gentleman, and what is due from one claiming to be a gentleman to other gentlemen. If so, no one can deny him the privilege. He is welcome so far as I am concerned to all the credit and to all the satisfaction that he may derive from such a course. I left the meeting, as I shall leave this, better satisfied with my own position—far better satisfied with my own position than with his. Now, I will tell you the facts in a word, in order that Mr. Fitzgerald may be saved the ignominy of leaving this room after having made another insinuation against gentlemen of the position of my colleagues. I say nothing worse than that, of having again made an insinuation. Of course, it must be a matter of surprise to any one who does not know all the circumstances that gentlemen who have gone through difficulties that I can give you no idea of, and brought the Company to a successful issue—that they should voluntarily throw up their positions as Chairman and Directors. That requires some explanation, but I had intended to spare you the trouble of receiving any in your own interests as shareholders. I am a shareholder, like yourselves. I and my colleagues have been anxious to hand this splendid property over to you without a blemish, without doing anything to prevent you from getting for your shares all that they are worth if you want to sell them, which is a great deal more, I am afraid, than you will get now. Therefore, after very careful consideration, on Saturday I wrote this circular, which I hope you have all received, in which I referred to the fact of our resigning, and endeavoured to do so with the least risk of doing you harm. I have received a number of letters from perfect strangers, who have asked me why we are resigning, from one who has protested against it, saying he took his shares in the Company on the faith of the present directors, and he desired to know why we were leaving. He told me that it was anomalous coupled with the report, and demanded to know the reasons, and finished his letter by telling me that under the circumstances he would hold me personally responsible for the return of his money in the Company. Well, gentlemen, I wrote in my circular:—"In reply to the several inquiries as to the reasons which have led me to resign, and Mr. Carnegy and Mr. Spensley not to offer themselves for re-election, I have to say that they are purely personal, and have obviously nothing to do with the present financial position of the Company, which is highly satisfactory, or with its prospects." I would have been glad to leave the thing there, but Mr. Fitzgerald, in the exercise of his greater wisdom, has chosen to make insinuations, or rather more than insinuations, and I propose to tell you what he meant to say. He meant to tell you that there is in the Board of the Consolidated Company a personal bitterness of feeling towards myself and certain of my colleagues that surpasses his powers of description, and that is saying a great deal. He has not attempted to tell you how bitterly he feels; he would have liked to have done so, but he has left that to me. Suffice it to say for your purposes that there is that feeling. Now, the Consolidated Company is your principal shareholder—rightly so because if the Consolidated Company had not supported you by this very credit which is involved in this debt you would not have been able to meet the demands—the enormous demands—for the extension of your system in Buenos Ayres and Monte Video. You could not have got the capital for the purpose. The Board before I joined it had several times tried to get it and had failed. Numerous efforts of ours had equally failed on account of this large debt. The Consolidated Company holds such a large controlling interest in the shares of this Company, that they could eject the Directors if they chose to do so, and at the time they could have ejected us if we had not resigned. Now, gentlemen, this is a statement of fact borne out by figures. Of course, Mr. Fitzgerald can do nothing without his colleagues. But they would probably take any course he recommended, and I think he would not stop short of any course to show his personal feeling towards ourselves. He would undoubtedly have tried to call an extraordinary general meeting of this Company for the purpose of putting us out. Well, it would depend upon whether he could control three-fourths of the shares of this Company; I do not think that he could do it—I have too much confidence in the common sense and the sense of fair play of the majority of Englishmen. We have over 100 shareholders, and the usual thing would have taken place—an extraordinary meeting, a committee of investigation—perhaps not even that, but formal resolutions to put us out—the result being that you would not be able to sell your shares at any price whatever. Now, that is what animated us in taking the course we have adopted. We have made this splendid property, and we are entitled to the credit of it—not entirely, perhaps, but, at any rate, to some of the credit. I am sorry that any one has misunderstood me in my personal circular, in which I pointed out how we found the Company when we came into it, and how admirably we leave it; but we have not taken all the credit to ourselves. I take it that you have all read the report which you have unanimously approved, and in that report we say "It will be observed that the net revenue for the year is £7,067 10s. 8d., as compared with £4,475 12s. 6d. for the previous year, showing the large increase of £2,591 18s. 2d., or, say, 58 per cent., a result which cannot but be extremely satisfactory to the proprietors, as it is to the Board, and for which the Board feel they are in no small degree indebted to the able and energetic management of their managing director in the River Plate, Mr. E. F. Powers, who has been ably supported by the local Board." It stands to reason that the local Board are entitled to more credit than ourselves if you like, but we are the Directors, and they are not.

In reply to Mr. CLARK,

The CHAIRMAN said that he had no doubt that the Telephone Construction Company would offer its shares in this Company to their shareholders as a means of raising fresh capital to carry on its various undertakings, and if the shareholders consulted their own interests they would take up the shares as a very good thing. Perhaps Mr. Fitzgerald would offer the shares to the shareholders of this Company; and it would only be fair if he did so, in which case he—the Chairman—only hoped that they would all increase their holdings.

Mr. FITZGERALD said that he should be only too glad to offer the shares to the shareholders of this Company if they liked to take them. So far as his Board was concerned, they were anxious to have the money. They had made this settlement by which they got shares because they could not get the money.

The CHAIRMAN having stated that he was very glad to hear that statement, the motion was put to the meeting and carried.

Mr. John Taylor and Major Henry Thomas George Fitzgerald were elected directors, and Colonel Gouraud, the Hon. Howard Spensley, and Mr. Patrick Carnegy resigned.

Messrs. Deloitte, Dever, Griffiths, and Co., the retiring auditors, having been re-elected,

Mr. FITZGERALD proposed that Sir Julius Vogel, who was entitled to a salary of £200 a year as a director, in consequence of his continued absence from England, and its probable duration, should be called upon to resign.

The CHAIRMAN ruled that the resolution was out of order, and said that the only way in which the matter could be dealt with was by calling an extraordinary general meeting.

The meeting was then made special, and a resolution was passed approving the terms of the settlement with the Telephone Construction and Maintenance Company.

A vote of thanks to the Chairman and Directors then terminated the proceedings.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. AUG. 20.		BUSINESS DONE WEEK ENDING AUG. 20. Highest.	Lowest.
Anglo-American	31½,	32½	32	—
Do. Preferred	55½,	56½	56½	56
Do. Deferred	7,	7½	7½	7⅜
Brazilian Submarine	10¼,	10½	10 7-16	10
Cuba	10½,	11	—	—
Do. Preference	16½,	17½	—	—
Direct Spanish	4½,	5	—	—
Do. Preference	15,	15½	—	—
Direct United States Cable	10,	10¼	10 7-16	10
Eastern Telegraph	11¼,	11½	11 7-16	11 3-16
Do. 6 per Cent. Preference	13,	13½	13¼	13⅛
Do. 5 per Cent. Debentures, 1890	103,	106	104½	—
Eastern Extension	11⅜,	11⅝	11⅝	11⅜
German Union	9¼,	9¾	—	—
Globe Telegraph and Trust	6⅜,	6⅞	6 13-16	6⅝
Do. Preference	12½,	12¾	12 11-16	12 7-16
Great Northern	13½,	13¾	13⅝	—
Indo-European	31½,	32½	32	31⅝
Reuter's	8,	8½	—	—
Submarine	165,	175	169	164½
West India and Panama	⅞,	1⅛	—	—
Do. 1st Preference	7¼,	7¾	7⅜	7¼
Western Brazilian	6⅜,	6⅝	6⅜	6¼
Western Union 7 per Cent. 1st Mortgage	123,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	106	105½	105¼

TELEPHONES.

Consolid. Telephone and Maintenance	3-16,	5-16	—	—
Oriental	⅛,	⅜	—	—
United Telephone	11½,	12	11¾	11¼

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1¾,	2	2	—
Do. (fully paid)	3¼,	3¾	3¼	—
Hammond Light (£3 15s. paid)	⅝,	⅞	—	—
Swan	—	—	—	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	33,	34	33¾	33½
India Rubber, Gutta Percha, and Telegraph Works	22,	23	23	22⅝

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NOTES.

AMOY.—The Great Northern Telegraph Company inform us that telegraphic communication with Amoy is restored.

EARTHQUAKE IN JERSEY.—A strong shock of earthquake was felt at Jersey on Tuesday morning, lasting about thirty seconds.

NAPLES.—A project is on foot for providing Naples with an underground railway, the tunnels of which it is proposed to light throughout by means of electricity.

BOOK RECEIVED.—"Dynamo-Electric Machinery," a manual for students of electro-technics. By Silvanus P. Thompson, B.A., D.Sc. Published by Messrs. E. and F. N. Spon.

ELECTRIC LIGHT FOR LOCOMOTIVES.—M. Sedlacyck's electric light for locomotives has been used on the engine "l'Erfurt," on the 3rd of this month, at the Steyr Exhibition, with great success.

ELECTRIC LIGHT IN PRESTON.—The contract for the electric lighting of the Park-lane Mills, Preston, has been given to Mr. F. D.'A. Goold, electrical engineer and contractor, 29, Arcade-chambers, St. Mary's-gate, Manchester.

MUNRO AND JAMIESON'S "POCKET BOOK."—We are informed that the first edition of this book has been sold, and that the second edition, with corrections and additions, is in hand and will be pushed forward as rapidly as possible.

TELEPHONY.—Mr. W. E. Irish, of Sunderland, has been trying his hand at an invention to automatically record the telephonic sounds as ordinarily transmitted by these instruments. It is doubtful if such a record is of much value.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 22nd August were £2,609, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE BENNETT-MACKAY CABLE.—The "Faraday" finished paying the deep-sea portion of the second Bennett-Mackay cable on Tuesday morning, and she returns immediately to Woolwich to receive the remaining deep-sea portion and the American shore end.

WHITWORTH SCHOLARSHIPS.—Four of the successful candidates at the last examination were students of the College of Science and Arts at Glasgow. We believe this is the first time so many successes have been gained at one institution in any single examination.

BRISTOL.—At the fire on the premises of Messrs. Platnauer, Victoria-street, the telephone was called into service both at the Talbot Hotel and at the cab stand, Bristol Bridge, and was found to be of great value in rapidly calling the attention of the fire brigade to the outbreak.

UNIVERSITY COLLEGE, LONDON.—The examination for the Gilchrist Engineering Scholarships will be held on the 25th September and following days. The Entrance Scholarship is of the value of £25; the value of the Senior Scholarship is £80. Full particulars can be obtained from the College.

CHINA.—The Eastern Telegraph Company and the Great Northern Telegraph Company notify that the telegraph system in China has now been extended to Pekin. Telegrams are therefore now accepted direct for that city, and need not be addressed "Post, Tungchow," as formerly, the rate being 10s. per word.

FRENCH ELECTRICAL POWER STORAGE COMPANY.—Notice has been given that the vacation judge has fixed the 3rd September, at twelve o'clock at noon, at the chambers of Mr. Justice Pearson, Royal Courts of Justice, Strand, London, as the time and place for the appointment of an official liquidator of this company.

EGYPT.—The mounted portion of the air line section of the Telegraph Battalion Royal Engineers has been ordered to proceed to Egypt to join the Expedition up the Nile, in addition to the dismounted portion already under orders. This portion will be under the command of Lieutenant Stewart and Lieutenant Bagnal.

TELEGRAPHISTS AND ATHLETICS.—The annual meeting of the London Electric Athletic and Cyclist Club will be held at Stamford Bridge, Fulham, S.W., on Saturday, 6th September. There is a good programme, including foot races, and bicycle and tricycle contests, for which, we understand, a liberal sum in the shape of prizes has been subscribed by the metropolitan telegraph officials.

CHINA.—The Great Northern Telegraph Company announces that the courier service from the landing point of the Shanghai-Foochow cable up to the latter town having been stopped by the Chinese authorities, telegrams for Foochow, as sent hitherto, will only be accepted at sender's risk. Telegrams for Foochow may, however, be forwarded *viâ* Shanghai by means of the Chinese land lines.

GLASGOW.—Mr. D. Prentice Munzies, of 106, Elliot-street, Glasgow, has received instructions from Messrs. James Pullar and Sons, dyers, Perth, to make a large addition to the electric lighting of their city works, Perth. It will at present comprise 150 incandescent 20 candle-power and 14 arc lights, also the general re-arrangement of their present electric light plant, which comprises no less than 20 dynamos.

LIGHTING BARRACKS.—The Government have decided to commence the system of lighting barracks by electric light by a trial at the Royal Engineers' barracks at Chatham, where favourable circumstances are found, during next year. The estimated cost is £5,000 for installation and £500 per annum for maintenance, and will give an annual saving of £400. Should the trial prove successful, the system will be extended.

AUTOMATIC ELECTRICAL BARRIERS FOR LEVEL CROSSINGS.—It is reported that the French railway companies are trying the American electrical barriers for level crossings. They are in a normal condition set across the lines, thus allowing the street traffic to be carried on; but, on the approach of a train, the locomotive wheels pass over a contact, and close a circuit, which causes the barriers to shut off the street traffic and give passage to the trains, at the same time warning the public by the continuous ringing of a bell.

THE BRITISH ASSOCIATION.—The Montreal meeting of this Association was opened on Wednesday evening, when the President, Lord Rayleigh, read his address, which will be found in another column. On Thursday evening there was to be a soiree, and on Friday evening Professor Oliver Lodge was to lecture on "Dust," a subject which he would no doubt render both interesting and instructive. The meetings of the various sections began on Thursday, and we shall hope to give the various papers of interest to our readers in an early issue.

FREEDOM OF WICK PRESENTED TO MR. PENDER, M.P.—A meeting of the Wick Town Council was held on Saturday last, when the freedom of the burgh was conferred on Mr.

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John Pender, member of Parliament for the northern burghs, on account of his assistance to the harbour authorities in the matter of the harbour loan. Mr. Pender briefly thanked the council for the honour done him, and assured them of his unabated zeal in harbour matters. Afterwards a public banquet took place in the Station Hotel, when the usual loyal and local toasts were given.

ELECTRIC WINCH.—The Northern Railway Company of France has adopted an electric winch for its goods depôt at La Chapelle, Paris. It consists of a four-wheeled truck, carrying the lifting apparatus and four small Siemens dynamos, two to act on the winch proper and two to propel the truck, the motion in both cases being transmitted by endless chains. Six men, including the engineer in charge of the dynamos and the fireman, can charge a hundred sacks, weighing together 10 tons, in a space of 48 minutes; and 38 minutes suffice when the winch has not to be displaced.

ELECTRIC LIGHT AT STEYR.—The current employed for lighting the palace of the Steyr Exhibition is supplied by sixteen dynamos, which supply as many arc lights. The manufactory of arms is lighted by eleven arc lamps. A great part of the town is lighted in the same manner. Another manufactory is lighted by three dynamos feeding 125 incandescent lamps, and another machine feeding seventy-five lamps. All these dynamos are worked by water or steam. The 203 arc lamps are nearly all of the Krucyi system, and the 450 incandescent lamps are of the Puluj system.

THE ELECTRICAL RESISTANCE OF ICE.—The resistance of ice has been measured by M. G. Foussereau. He says he determined the resistances of ice made from distilled water by taking for electrodes two thin cylindrical and concentric plates of platinum. He found the resistance became 15,000 times greater at the moment of congelation. The specific resistances varied from 4,865 megs. at – 1deg. C. to 53,540 megs. at – 17deg. C. "I found also," he says, "that the resistance of ice varies with the nature of the water from which it is made. A sample of town water 65 times better conductor than the distilled water previously mentioned gave ice conducting 30 or 40 times better."

TELEPHONING EXTRAORDINARY. — Experiments in telephoning to long distances have been made by the engineers of the International Bell Telephone Company between St. Petersburg and Bologœ (about 3,700 kilometres = 2,465 miles). Blake transmitting and Bell receiving instruments were used; and conversation could be kept up notwithstanding a rather high induction. It is but right to add that the experiments were made during the night, when the telegraph lines were not at work. The Russian engineers hope to succeed in speaking to a distance of 7,000 kilometres (4,665 miles), but to do this they must have combined all the conditions favourable to transmission.—*Bulletin de la Compagnie Internationale des Téléphones.*

SIXPENNY TELEGRAMS.—A writer in the *Daily News* of Wednesday happening to be in a post office in the City on the previous day, saw a gentleman hand in a telegram for Brussels, for which he paid sixpence. The clerk at the counter also informed him that messages were frequently sent to Bordeaux, Marseilles, and other places in France, at a cost of sevenpence halfpenny. Our contemporary's correspondent compares these rates with the costly shilling that must be paid if he wished to telegraph to a friend "only a few doors off in London." He opines that that this state of things should not be allowed to continue, and hopes the Post Office "will not be allowed to quietly drop their long advertised project of a reduction of the inland telegram rate to sixpence."

BOATING ON WINDERMERE BY ELECTRICITY.—A boat, driven by electricity, owned by Mr. J. R. Bridson, of Belle Isle, Windermere, and which is intended to be used by him to keep up communication between his island residence and the mainland, has just been tried. She is 21ft. long by 4ft. 6in. wide, and has ample accommodation for nine or ten persons. The electromotor is the invention of Reckenzaun, of London; and the power which supplies the motor is derived from twenty secondary batteries or accumulators, charged primarily by the dynamo machine used at a Bolton bleachworks for lighting purposes. The whole of the machinery is so disposed in the boat that it is not visible to the passengers. The ordinary pace will be ten miles per hour, which can, however, be easily increased. The screw is 12in. in diameter, with 11in. pitch, and makes 450 revolutions per minute.—*Northern Echo.*

ELECTRICITY AND CHOLERA.—"Amongst the means of fighting cholera," says the *Annales de l'Electricité*, "ozone is considered one of the most successful. It is supposed that this gas destroys the germs suspended in the air, and it is to its production that turpentine, lavender, and thyme owe their disinfectant qualities. Dr. Vigoroux has proposed a means for obtaining ozone in times of epidemics. He would electrify patients on an insulated stool by a simple static electric machine. The well-known smell of ozone becomes more marked if without causing a spark a conductor is approached to the patient. By this means ozone is not only given up to the air, it is produced at the very surface of the body—that is to say, at the very limit that the poisonous agent must itself pass to become dangerous. It is a kind of atmospheric breastplate against the invasion of microbes. We may add that many years ago we have heard of induction coils being used in hospitals to give off ozone."

WHAT AMERICANS THINK OF OUR CABLE MANAGEMENT.—The *Morning Journal* of New York says that:—"Efficient and able management is the key to success in all business enterprises, and in none more so than in cable service. The Direct United States Cable Company is an example of this. Splendidly equipped and with ample means behind it, nevertheless to the lynx eyed and skilled direction of Mr. John W. Fuller, its secretary and traffic manager, it owes that perfection of organisation which has meant profit for its owners as well as satisfaction to its patrons. That Mr. Fuller has brought his fine executive abilities and notable electrical knowledge to bear, under the still higher leadership of Mr. John Pender, the great cable king, is perhaps the ultimate reason of its success. At its six-monthly meeting on the 25th ult. it showed that over 250,000dols. went to the account of profit for the half year—a splendid result of great energies unremittingly devoted to the care and prosperity of a great property."

A WATERSPOUT.—During a thunderstorm a few days ago a singular phenomenon, which is more often observed at sea than on land, was witnessed at Simmondley, a village about one mile from Glossop. Behind the village rise precipitous hills, which girt part of the hamlet in something like the shape of a horseshoe, and in the centre of this runs a deep clough. When the storm was at its height the villagers became affrighted by a terrible thunderclap, which seemed to rend the heavens. In a moment or two an immense volume of water, carrying with it large quantities of earth and stones, rushed down the clough and flooded some of the cottages five feet deep with water.

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The phenomenon was described by the natives as "the bursting of a cloud" (literally a waterspout), and its tremendous force may be gathered from the fact that where the water rushed to the earth it made a great indentation in the hill side sufficiently large in width and length to enclose a house. The cavity is about 12 yards long and nearly 8ft. deep.

A Cataract Lighted by the Electric Light.—Our contemporary *L'Electricité* has a full-page woodcut showing one of the cataracts on the Rhine, near Schaffouse, lighted by the electric light. It appears that the Steam Navigation Company on the Rhine and Lake Constance have inaugurated a night service with steamers having Bürgin lamps, for lighting the picturesque banks of the river. The boat started at nightfall from Schaffouse and made the passage as far as Biesengen. During the passage the passengers were enabled to admire the river and its banks lighted as if by daylight; the pilot could pick out at a distance the various beacons placed close to the water level, and could even bring the steamer alongside at Biesengen without the slightest danger. But not contented with merely lighting the steamers along their road, and to show off the cataracts or falls in a more imposing manner a powerful electric arc was placed on the right bank of the river, throwing its beam on the well-known falls of Schaffouse.

Signalling between London and Portsmouth.—Arrangements have been made by Major Thrupp, Inspector of Army Signalling, to place London and Wimbledon in communication with the Spithead forts by day and night for three days this week, the general idea on which the experiments are being carried out being that an enemy having landed on the South Coast and intercepted telegraphic communication between Portsmouth, London, and Aldershot, communication has to be maintained by signalling by means of flags and the heliograph by day, and by night with the flashing lamp and a system of rockets. The stations are Wimbledon to Epsom Downs, eight miles; Epsom Downs to Merrow Downs, near Guildford, thirteen miles; Merrow Downs to Hungry Hill, twelve miles; Hungry Hill to Hind Head, ten miles; Hind Head to Butser Hill, near Petersfield, fourteen miles; and Butser Hill to the Spithead forts, fourteen miles. To enable practice at longer distances, Merrow Downs and Hind Head were cut out for a time, so that the messages went from Wimbledon to Epsom, Epsom to Hungry Hill, Hungry Hill to Butser Hill, and Butser Hill to the Spithead forts, thus giving two distances of over twenty miles. At the time of writing we do not know the amount of success obtained in this experiment.

The Electric Light at the Law Courts.—The installation of machines and engines has hitherto been only temporary, being in an iron shed on the waste ground to the west of the building. The permanent plant will be placed in the crypt under the great hall. This change involves a considerable amount of labour, as the existing steam boilers, which were only designed for the ventilation of the building, will have to be removed, as also will nearly all the existing steam and exhaust pipes as well as several large tanks. When completed there will be two 100 horse-power Galloway patent boilers, two single cylinder horizontal engines, each indicating 105 H.P., at 60 revolutions, either one being capable of doing the whole of the lighting. The requisite speed for the dynamos, about 1,100 revolutions, will be obtained by two sets of shafting, with friction clutches on the first, so as to allow either or both the engines to be worked as necessary. Six Crompton-Burgin compound wound 10-unit machines, all coupled parallel, will produce the current for the general illumination, lighting about 650 twenty candle-power Swan lamps. A small Willans high speed engine, with electric governors, will drive a 6-unit machine for lighting an all day circuit of about 45 lamps. There will also be two Burgin series machines, each lighting a series of three 4,000 candle-power Crompton-Crabb arc lamps, in the central hall. The engines, boilers, &c., are being fitted by Messrs. Galloway and Sons, and the dynamos, cables, switch boards, &c., by Messrs. R. E. Crompton and Co., who fitted and wired the building, and under whose supervision the lighting was carried on until May last, when it was taken over by the Government, under the control of Her Majesty's Office of Works.

E.M.F.—Mr. G. Chaperon writes in the *Comptes Rendus* on a probable cause of the difference between the observed electromotive force of galvanic couples and that calculated from thermo-chemical data:—"Amongst galvanic couples which have an actual electromotive force considerably different from that calculated from thermo-chemical data, there are several which seem to exhibit phenomena due to the polarisation of the dissolved metal, and although these couples have a positive electrode which cannot polarise, they yield a current, the electromotive force of which falls very rapidly to zero. The author has determined the E.M.F. of several couples of this kind, and finds that they constitute systems which are polarisable up to the point of decomposition of the electrolyte into its elements, the difference of potential between the two electrodes increasing between zero and the point of electrolysis, and even beyond the latter, in accordance with an uninterrupted law. If $T\,m\,R$ and $T\,m\,H$ represent the work or electric energy corresponding, at a given temperature and pressure, with the absorption or restitution of the elements R and H of an electrolyte, by an electrode of the polarisable metal *m*, then $T\,m\,R$ and $T\,m\,H$ are not constant, but vary between very wide limits, diminishing as the proportion of R and H absorbed increases. It follows that the chemical work corresponding with the electric energy given back by the two polarised electrodes will generally be $T\,R\,H - T\,m\,R - T\,m\,H$, where $T\,R\,H$ is the energy of formation of the electrolyte. When polarisation follows an uninterrupted law, this value of the chemical energy will vary from $T\,R\,H$ to zero, between the point of electrolysis and the state of neutrality of the electrodes which is represented by the equation $T\,R\,H - T\,m\,R - T\,m\,H = 0$. Between the same limits, $T\,m\,R$ and $T\,m\,H$ will vary from zero to two positive values, each of which will, at the limit, be smaller than $T\,R\,H$, and it is the value of $T\,m\,R$ satisfying equation (1) which ought to be used instead of the heat of combination in calculating the theoretical E.M.F."—*Chem. Soc. Journal.*

The French Balloon Experiments.—Further light is thrown on the recent balloon experiments at Meudon by the following telegram from the Paris correspondent of the *Standard*, which is dated Tuesday night. He says:—"Messrs. Renard and Krebs' reported discovery of a steerable balloon occupied the Paris Academy of Sciences again yesterday. A letter was read from M. Dupuy de Lome, a member of the Academy, well known as a zealous labourer in the science of aeronautics. It is, in fact, by the principles laid down by M. Dupuy de Lome that Messrs. Renard and Krebs have been guided in the construction of their balloon. In the letter referred to M. Dupuy de Lome affirms that his own experiments in 1875 conclusively proved the practicability of guiding balloons in a horizontal direction. His machinery, however, did not permit a greater speed than 10 kilometres an hour, and this was not sufficient in face of a wind of

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any superior degree of velocity. Messrs. Renard and Krebs will, however, says M. de Lome, employ, in an experiment to be made at an early date, a motor of a double power to that which he had used, and attain a speed of twenty-five kilometres per hour. The great progress made is, he adds, the invention of a machine which, including batteries and accessories, weighs only five hundred and sixty kilogrammes. M. Dupuy de Lome expresses himself altogether very sanguine upon the achievements of his fellow labourers, but it will seem to most people that light as the new electric machinery may be in comparison with that hitherto experimented with, a weight of five hundred and sixty kilogrammes is a dangerously large proportion of the total weight, namely, two thousand kilogrammes, of Messrs. Renard and Krebs' balloon. Various explanations are given of the reasons preventing the aerial voyage from Meudon to Paris last Saturday, which thousands of persons had assembled to witness. The truth is, that in the previous experiment the machinery had been damaged, and some modifications of detail had been judged desirable before further experiments were undertaken."

SIMULTANEOUS TELEGRAPH AND TELEPHONE MESSAGES.—M Van Rysselberghe and the telegraphic engineers of the Belgian Government are now engaged in completing the arrangements and modifications necessary for the simultaneous transmission of telegraphic messages and telephonic conversations. The Bell Telephone Company is also carrying out some important works in its central offices, as well as laying down junction lines, so as to permit of its subscribers using their instruments for distant speaking. At Brussels alone the length of the lines laid down for this purpose is nearly 70 kilometres = 45 miles. This brings up the length of wires in Brussels and its neighbourhood to over 1,100 kilometres = 730 miles, serving more than 600 stations. The total length of this company's wires in Brussels, Antwerp, Ghent, Verviers, and Charleroi is about 1,500 kilometres = 1,000 miles, serving more than 2,500 stations. Independently of the conceded lines, there are a number of private lines in Belgium established on the property of their owners. By the connecting of certain stations already in communication with the central offices, telephone lines of 15 and 20 kilometres, or 10 and 15 miles, have been worked. In the Antwerp concession, with which is connected the military system of that city, there is a combination of lines having a length of 33 kilometres or 22 miles. This combination is complicated by the intercalation in the circuit of five calling signals, which by their additional resistance, still further increase the total resistance. Notwithstanding this fact, the calls by the magneto-electric bells, imported into Belgium by the International Bell and Telephone Company, of New York, as also the telephonic communications by means of Blake microphones and Bell receiving instruments, are made without difficulty. Moreover, experiments have been made in Belgium, even on the longest line in the kingdom, with Blake and Bell instruments; and between Ostend and Arlon, a distance, as the crow flies, of 270 kilometres or 180 miles, telephonic messages have been exchanged by these means.—*Bulletin de la Compagnie Internationale des Téléphones.*

ELECTRIC RAILWAY IN CLEVELAND, U.S.—With reference to the trial trip of the new electrical street car invented by Messrs. Knight and Bentley, late of the U.S. Patent Office, and constructed by the Brush Electric Company, which took place on the Garden-street line of the East Cleveland Street Railroad Company, referred to in our last issue, the Cleveland *Iron Trade Review* of August 2nd adds the following particulars:—About a mile of the track on the former line, running out of New and Quincy streets, had been prepared for the test by the construction of a boxed trench, running between the rails, receiving the two small channel irons, which served as conductors of the electricity. Beneath the centre of the car was boxed the motor, a 15 horse-power Brush dynamo, connected with which were four coil wires, passing over large pulleys located beneath the seats, thence transmitting the motion to the axle. The action of this lever at the front of the car caused a copper brush, running in the channel, to come in contact with the electrical conductors; the armature began to revolve rapidly, and the axles and wheels of the car were propelled forward, at first slowly, at length at a speed of probably five miles an hour, though the inventors claim that from 8 to 15 miles an hour can be obtained. The electricity was generated by a 30 horse-power dynamo (*sic*) located some four miles away, and conducted to the street car barns on a No. 6 wire. Ultimately, it is the intention, we understand, to locate a full electric power plant at the main stables of the street car company on Euclid-avenue. The results of Saturday's experiments were satisfactory, though, of course, by no means complete. The car, loaded with passengers, made two short trips, running smoothly, rounding curves, and obeying the lever quickly. On Monday much more desirable results were reached, the car being run to Woodland Avenue Cemetery, a distance of about three-quarters of a mile; but by reason of the breaking of some portion of the apparatus it had to be taken back to the barns for repairs. It may be remarked that this piece of track is probably the roughest to be found in the city of Cleveland.

AN ELECTRIC TORPEDO BOAT.—Professor Tuck's electric submarine torpedo boat looks at a little distance very much as if it had been constructed by laying a large row boat upside down, on top of another large row boat, fastening it there, and painting them both sea green. The shell is of iron, however. The boat is 30ft. long. It is ballasted with lead, so as to sink to the water's edge, and its displacement is 20 tons. In the centre of what may be called the deck is sunk a well hole. By a simple air lock arrangement it affords a passage between the interior and the exterior of the vessel, even when the vessel is wholly under water. It is also the captain's look-out station, and is capped with a dome of heavy glass, so that if he chooses he can exclude the water and stand in the pit with his head and shoulders above the top of the boat, or he can leave the glass off and stand there in a diving suit. Close to his hand is a signalling steering apparatus, which transmits his orders to the helmsman down below. The boat has three rudders, one an ordinary vertical rudder at the stern, and the other two horizontal blades on the port and starboard quarters. These last help to govern the boat's movements up and down. To sink her, water is pumped into her compartments; to raise her, air is pumped in, and the water is forced out. Compressed air is stored aboard in six inch pipes. There is also an apparatus for reoxygenating air that has already been breathed. Moreover, there is a simple arrangement by which the ends of two rubber tubes can be floated up to the surface of the water and opened to the supply of fresh air up there. An electric motor, driven by force from storage batteries, runs the propeller. The interior, which is arranged for a crew of four or five men, is lighted by incandescent lamps. An indicator shows the distance of the boat beneath the surface. The estimated speed of the boat under water is eight knots. The torpedoes are to be carried outside the vessel, one at the prow and one at the stern. They are to be held there in

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iron cylindrical sheaths by electro-magnets, which will release them when the current is cut off. They are ballasted with cork, and after placing one of them the torpedo boat retires to a distance, unreeling as it goes two wires, by which, at a proper distance, the torpedo is fired. The lead ballast proved insufficient to sink the boat below the water. On a recent trial near the Delamater Iron Works, New York, a crew of three men went aboard her, and, with Mr. John Rice as captain, a test was made of the electric engine. It drove the boat several miles up and down the river at a speed of ten knots, says the New York *Sun*. She answered her rudder well. She will soon be tried under water.

Electric Lighting.—The Board of Trade report that four applications for provisional orders were received on or before December 21st, 1883. One of these applications was made by a local authority, and the remainder by companies. The names of the applicants and the districts proposed to be lighted were:—1. The Edison and Swan United Electric Lighting Company; the object of this order was to transfer to the Edison and Swan United Electric Lighting Company certain rights, powers, and obligations conferred upon the Edison Electric Lighting Company by the provisional orders granted to those companies last Session in respect of various districts in the metropolis. 2. The Mayor, Aldermen, and Burgesses of the borough of Bury St. Edmunds. 3. The Telegraph Construction and Maintenance Company and the West London Electric Lighting Company, or one of them. 4. West Middlesex Electric Lighting Company. All these applications were granted by the Board of Trade. These have now received the Royal assent. All the sixty-nine provisional orders granted by the Board of Trade last Session were subsequently confirmed by Parliament. The orders granted to companies contained provisions either that the undertakers were to satisfy the Board of Trade that they were in a position to carry out the compulsory works or to appropriate a certain sum as a separate capital for the purposes of the undertaking, and to deposit or secure a specified sum of money to the satisfaction of the Board of Trade. In the event of these requirements not being complied with within a period of six months from the commencement of the order, or such extended period as might be approved by the Board, the Board of Trade were empowered to revoke the order on such terms as they might think just. The above period of six months expired on the 25th February, and before that time applications were received from the undertakers of all the orders (except one where the promoters had already gone into liquidation) for approval of an extension of time. After consulting the various local authorities concerned, the Board of Trade approved of an extension of time in 24 cases, and declined to approve of the others, in some cases in consequence of the opposition of the local authority, and in the case of the Metropolitan Brush Electric Light and Power Company, because that company had decided to liquidate its affairs. Applications were later made for a further extension of time as regards the orders of the Incandescent, the Provincial Brush, and the South-Eastern Brush Companies; in some cases the further extension was granted, and in other cases they are still under consideration. The Board of Trade are advised and propose to revoke those orders in respect of which no extension of time has been approved. Thus electric lighting, says the *Mechanical World*, in public is making little or no progress, and the field is left open to the gas companies.

Electricity Among the Ancients.—In Dr. Falconer's "Observations on the Knowledge of the Ancients Respecting Electricity," we have an account of amber, whether from Liguria or the north, and of Lapis Lyncurius "which attracts straws and leaves, copper and iron," and of electric fishes, subjects now better known to the ordinary reader; we have, however, less known speculations suggested to Dr. Falconer by "an ingenious and learned gentleman," on the knowledge of the Etruscans, familiar also to Numa Pompilius, who is said to have drawn fire down from heaven. This statement is corroborated by the manner of his successor's death. Tullus Hostilius was killed, the ingenious gentleman supposes, by mismanaging the process of bringing down the lightning. This is a fair explanation of the matter, and in the words of Livy, 'tradunt ira Jovis sollicitati prava religione, fulmine ictum cum domo conflagrasse." Livy says of him "that after examining the commentaries of Numa and finding there a description of certain occult and solemn sacrifices performed to Jupiter Elicius, he set himself to execute these in private; but from some impropriety in the commencement and conduct of these operations, he not only failed of being favoured with any intercourse with any celestial beings, but was, through the wrath of Jove, excited by his being importuned with such irregular rites and ceremonials, struck with lightning, and consumed together with his palace." We throw aside all these things in our new histories, and Numa Pompilius becomes an idea, like the frogs of Marcus Marci. Dr. Falconer's extract from Lucan is also very interesting, saying that the Etruscan Aruns collected the fires of heaven, and buried them in the earth with sad murmur. "What is this," he says, although the words have inverted commas as if they were a quotation, "What is this but the description of the use of a conductor to secure buildings from being struck by lightning?" The words are:—

> "Dumque illi effusam longis anfractibus urbem
> Circumeunt, Aruns dispersos fulminis ignes
> Colligit, et terræ mæsto cum murmure condit."

It certainly reads as if the fire itself were collected, but we fear the critics and dictionaries are against Dr. Falconer, and consider that it was the place struck by lightning or the objects struck. *Fulgur*, we are told, is an object struck by lightning, and the *Bidental* a place struck by lightning; both, however, have a sacredness, or at least awe, attached to them. In "Lucan's Pharsalia," translated by H. D. Riley, B.A., B. I., 585—599, we have—"Of whom, Aruns, the one most stricken in years inhabited the walls of deserted Luca, well skilled in the movements of lightnings, and the throbbing veins of the entrails, and the warnings of the wing hovering in the air." B. I., 503—610, "And while in prolonged circuit they go round about the emptied city, Aruns collects the *dispersed objects struck* by flames of lightning, and with a lamenting murmur buries them in the earth, and bestows a name upon the consecrated spots. Then does he urge onward to the altar a male with selected neck." Still, without pretending to a critical knowledge of Latin, we must seek some evidence that *ignes* meant the things struck by fire. If we look at Smith's Dictionary, we find that the priests "Bidentales" collected the earth and buried it in the ground with a sorrowful murmur, but the proof of this painful expression is the very passage in question, and we may yet ask if *condere fulgur* means the same as *colligere dispersos fulminis ignes*. Dr. Falconer seems to have found the truth hidden from the scholars unskilled in physics. He then endeavours to trace the use of spears as conductors, and quotes Livy's account of a spear which burnt for two hours and was not consumed. He gives Plutarch's account of balls of fire that were seen on the points of the soldiers' spears, and refers to the lightning on ships' masts, and the fires of St. Elmo. This connects the worship of spears with fire worship.—From "A Centenary of Science in Manchester," by R. Angus Smith, F.R.S., Ph.D., LL.D.

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THE INDUCTION OF CURRENTS IN CORES.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 339.)

Determination of Constants—Conjugate Property.

Referring to Fig. 2, by superimposing any number of normal systems, of which the first four only are shown, taken of any absolute magnitudes, we may produce an immense variety of distributions of magnetic force. They will all, by the manner of their conduction, be decomposable into the normal systems from which they arose. Now, by the reasoning previously stated, when the whole series of normal systems is taken, we may, by properly choosing the values of the A's in the series $A_1v_1+A_2v_2+\ldots$, make it represent *any* chosen function of r; of course single valued. The decomposition of the given function into normal systems is most easily effected by making use of the conjugate property $\int v_1v_2rdr=0$, possessed by every pair of different normal functions, the limits of integration being 0 and a, the axis and the boundary of the core.

The proof is easy. For u_1 and u_2, by (67), satisfy

$$\frac{1}{r}\frac{d}{dr}r\frac{dv_1}{dr}+n_1^2v_1=0, \text{ and } \frac{1}{r}\frac{d}{dr}r\frac{dv_2}{dr}+n_2^2v_2=0.$$

Multiply the first of these by v_2r, the second by v_1r, subtract the second result from the first, and then integrate with respect to r from $r=0$ to $r=a$. We find immediately,

$$(n_1^2-n_2^2)\int v_1v_2rdr=\Big[r(v_1v'_2-v_2v'_1)\Big]_0^a \quad . \quad . \quad (76)$$

the accents denoting differentiation to r. The right hand number vanishes at both limits, because v_1 and v_2 vanish at $r=a$, v'_1 and v'_2 being then finite; whilst both factors of rv'_1 and rv'_2 vanish with r, v_1 and v_2 being then finite. Hence, if n_1 and n_2 are different, we have

$$\int v_1v_2rdr=0; \quad . \quad . \quad . \quad . \quad . \quad (77)$$

the conjugate property to suit the present case. Now, given H_0 as a function of r, the initial distribution, to expand it in v's, thus

$$H_0=A_1v_1+A_2v_2+A_3v_3+\ldots,$$

multiply both sides by rv_1dr and integrate between limits 0 and a. We get

$$\int H_0rv_1dr=A_1\int v_1^2rdr;$$

since, by (77), all the rest vanishes. This gives the value of A_1, and similarly for the other coefficients, any one being given by

$$A=\frac{\int H_0vrdr}{\int v^2rdr} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (78)$$

Using the particular u concerned. The denominator may be evaluated by (76). For, if in (76) we make $n_1=n_2$, making $v_1=v_2$ and $v'_1=v'_2$, it assumes the form $0\times\int v^2rdr=0-0$, and the integral, being the sum of squares, and therefore not vanishing, is to be found by the ordinary process. Differentiate (76) with respect to n_1^2, and then make $n_1^2=n_2^2=n^2$; this gives

$$\int v^2rdr=\Big[r\Big(\frac{dv}{dn^2}v'-v\frac{dv'}{dn^2}\Big)\Big]_0^a \text{ generally,} \quad . \quad . \quad . \quad (79)$$

$$\text{and } =av'\frac{dv}{dn^2}, \ (r=a), \text{ in present case.}$$

Now $\dfrac{dv}{dn^2}=\dfrac{1}{2n}\dfrac{dv}{dn}$, and, by (70), $\dfrac{dv}{dr}=n\dfrac{dv}{dn}$; therefore,

$$\int v^2rdr=\frac{a^2}{2n^2}\Big(\frac{dv}{da}\Big)^2=\frac{a^2}{2}\Big\{J_1(na)\Big\}^2 \quad . \quad . \quad . \quad (80)$$

$\dfrac{dv}{da}$ being the value of $\dfrac{dv}{dr}$ at $r=a$. Hence, by (78) and (80)

$$A=\frac{2n^2}{a^2}\frac{\int H_0vrdr}{\Big(\frac{dv}{da}\Big)^2}=\frac{2}{a^2}\frac{\int H_0vrdr}{\{J_1(na)\}^2} \quad . \quad . \quad . \quad (81)$$

Thus, when H_0 is given, the expansion is effected, and the magnetic force is known at any subsequent time.

$H_0=$ *constant.*

Put a battery on the coil circuit. It sets up ultimately $H_0=$ constant in the core. Break the circuit, or make its resistance very high, removing the E.M.F. Never mind the slight loss of energy in sparking, as, the core being free for induced currents, nearly all the energy will be dissipated therein. We can now evaluate the numerator in (81).

$$\int H_0rvdr=H_0\int rvdr=-\frac{a}{n^2}\frac{dv}{da}=+\frac{a}{n}J_1(na)$$

by (70) first, integrating, and then comparing with (74). This makes (81) become

$$A=2H_0/naJ_0(na),$$

and the complete solution is therefore

$$H=2H_0\Sigma.\frac{J_0(nr)}{J_1(na)}.\frac{e^{Dt}}{na} \quad . \quad . \quad . \quad . \quad (82)$$

the numeration to include all values of n.

The current density is got from this by differentiation; thus

$$\gamma=-\frac{1}{4\pi}H'=+\frac{H_0}{2\pi}\Sigma\frac{J_1(nr)}{J_1(na)}\frac{e^{Dt}}{a} \quad . \quad . \quad . \quad (83)$$

In establishing the solution (82) of the most simple case that presents itself (curve to be given in Fig. 3), we have entered more into detail than at first intended; as a refresher to the memory of readers who are acquainted with the methods employed, for the education of readers who may be only learning them, and because in the more complex cases to follow much of the reasoning will be exactly similar, so that the investigations may be given more briefly without loss of intelligibility. At the same time, there are numerous details and side matters of interest that must be omitted. Otherwise, we should "go on for ever," like the brook in lordly Alfred's charming poem, that came from haunts of cocks and hens, and made a sudden sally, and rumbled in and out the fern, and tumbled down a valley, with a number of other pranks, proclaiming at equidistant intervals its superiority to man in the constancy of its circulation.

Magnetic Energy and Dissipation.

The magnetic energy per unit volume being $\mu H^2/8\pi$, the amount T in unit length of core, by (82) and the conjugate property (77) making products vanish, is

$$T=H_0^2\frac{4\mu}{8\pi}\int_0^a 2\pi rdr\Sigma\frac{J_0^2(nr)}{J_1^2(na)}.\frac{e^{2Dt}}{n^2a^2}=\frac{\mu}{2}H_0^2.\Sigma\frac{e^{2Dt}}{n^2}. \quad (84)$$

by integrating, and using (80). (In these series it is of course only necessary to operate on one term, since they are all alike in their properties.)

This, of course, vanishes ultimately, the D's being negative. At starting, $t=0$, we know, from H being constant, that $T=\pi a^2\mu H_0^2/8\pi=\mu a^2H_0^2/8$; hence we must have, by (84),

$$\tfrac{1}{8}\mu a^2H_0^2=\tfrac{1}{2}\mu H_0^2\Sigma n^{-2}; \text{ or, } \tfrac{1}{4}=\Sigma(na)^{-2},$$

the values of na being those in (75), and their companions. This is true, for, examining the form of the expansion (70) of $J_0(nr)$, the sum of the squares of the reciprocals of the roots of $J_0(nr)=0=$ coefficient of the second term with the sign changed, *i.e.*, $\frac{1}{4}$.

To test that, the formulæ make all the energy be dissipated in the core according to Joule's law; the heat per second per

unit volume being $\rho\gamma^2$, the total per unit length of core, from the beginning to the end of the discharge, by (83), is

$$\frac{\rho H_0^2}{2\pi a^2}\int_0^\infty dt \int_0^a rdr \Sigma \frac{J_1^2(nr)}{J_1^2(na)} e^{2Dt} ; \quad . \quad . \quad . \quad (85)$$

where again we omit products, on account of the conjugate property of the normal systems of current, thus proved.

$$J_1(n_1r)\, J_1(n_2r) rdr = \frac{1}{n_1 n_2}\int \frac{dv_1}{dr}\frac{dv_2}{dr} rdr = \frac{r}{n_1 n_2}. \frac{n_1^2 v_1 v_2' - n_2^2 v_2 v_1'}{n_1^2 - n_2^2} \qquad (86)$$

by integrating and using (79). This vanishes when the limits are 0 and a.

Evaluating by differentiation for the case $n_1 = n_2 = n$, we get

$$\int_0^a J_1^2(nr) rdr = \frac{a^2}{2} J_1^2(na) \quad . \quad . \quad . \quad . \quad (87)$$

and using this in (85), we obtain, after integrating to t as well,

$$-\Sigma \frac{\rho H_0^2}{8\pi D}, \text{ or } \frac{\mu H_0^2 a^2}{2} \Sigma \frac{1}{(na)^2} = T, \ (t = 0),$$

as before found.

(TO BE CONTINUED.)

THE ELEMENTS OF ELECTRIC LIGHT ENGINEERING.

BY C. W. S. CRAWLEY.*

(CONTINUED FROM PAGE 343.)

Before starting a dynamo machine the collector or commutator should be well examined to see that it is properly clean; if not, it should be cleaned by rubbing it with a piece of linen rag, and then it should be just touched with oil (preferably lard oil) by holding an oily pad of clean wash-leather lightly against it when rotating. This ought to be done several times in the course of the day if the machine be running continuously. In the case of the Brush dynamo it should be done every half hour or hour. The brushes must be looked to; they should press evenly and firmly against the collector, but ought not to be screwed against it too tightly, or they will wear out very fast. When this happens, and they become ragged and uneven, they should be taken off, trimmed with a pair of shears, and then replaced. In putting the slit metal brushes on the Brush machine they should be clamped in the brush holders, so that when the machine is turned against the brushes the edges of the air insulation spaces on the commutator just do not catch the forward edges of the brushes.

See that the lubricators for the bearings are well supplied with oil before starting, and are in good working order, and that there is nothing† lying about that may catch in the armature when revolving. If on starting the machine and turning on the current there is much sparking at the brushes, it shows that their lead is wrong, and they must either be advanced slightly in the direction of rotation, or *vice versâ*, until the sparking is reduced to a minimum. In some machines the brush holders are mounted on a rocking arrangement, and so can be easily shifted when the machine is running; in the others the shifting must be done by putting the brushes further in or out of their holders.

When the current that a machine is generating is increased or diminished, increased sparking will probably be seen at the brushes, necessitating an alteration of the lead; as a general rule, if the current be increased the lead must be also increased, *i.e.*, the brushes must be slightly advanced in the direction of rotation, and *vice versâ*.

In altering the lead on a Brush machine where there are two or three pairs of brushes, each pair on a separate rocking arrangement, the first pair should be shifted very slightly forward or backward, as the case may be, then the next pair in the same manner, and, if there are three pairs, the third; then the first again, and so on, until all the pairs have the proper lead.

As we have several times mentioned the Brush machine without having described it, we shall now do so. The armature of this dynamo consists of a ring with projecting teeth, between which the coils are wound. There are eight of these coils, the inner end of four of which is joined to the inner end of the one diametrically opposite to it, while the outer ends are brought to the various segments of the commutators, of which there are two or three. When the machine is working, one pair of coils—that in the least useful part of the field (*i.e.*, when the rate of change of the lines of force passing through them is a minimum)—is cut out of action. The pair of coils at right angles to these, which is in the most useful part of the field, is in contact with one pair of brushes, while the other two pairs of coils, which are neither in their best nor worst positions, are joined together in parallel arc between the other pair of brushes. The two pairs of brushes and the coils between them, the field magnets, and the external circuit are all in series, as shown symbolically in Fig. 21, where the pair of coils between the brushes A A′ is in the best position in the field, and the two pairs in parallel between B B′ are in fairly good positions, each of these latter pairs having the same E.M.F. developed in it.

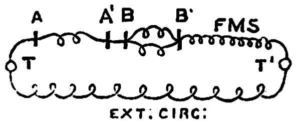

FIG. 21.

A A′ are one pair of brushes touching one commutator, and B B′ the other. For one eighth of a revolution there is one pair of coils in the best position between A A′, and two pairs in parallel between B B′; for the next eighth one pair in the best position between B B′, and two pairs in parallel between A A′; then, as before, for the next eighth, and so on, each pair of coils being cut out of circuit twice every revolution. The resistance, therefore, of a Brush machine consists of the resistance of one pair of coils plus half the resistance of one pair plus the resistance of the field magnets. If the resistance of the field magnets equals three ohms, and that of one pair of coils equals 1·215 ohm, the internal resistance of the machine is 1·215 + ·607 + 3 = 4·822 ohms, which is the resistance of a six-light machine.

In some machines the field magnets are connected up between the two pairs of brushes, *i.e.*, between A′ and B. The field magnets consist of two north poles, with large flat pole pieces placed opposite one another, and also two south poles placed in the same manner.

The Shunt Dynamo.

The next dynamo we shall consider is the shunt. In this machine the field magnets are wound with a great length of fine wire so as to have a high resistance, and are arranged in multiple arc with, or (as its name implies) as a shunt on, the external circuit.

As will be seen from Figs. 22 and 23, each brush is connected to one of the terminals and also to one of the ends of the fine wire with which the field magnets are wound. When the armature is rotated and a current generated in it, this current goes out by the + brush B to the terminal T, where it divides, part flowing round the field magnets F M, and part through the external circuit P (the proportion flowing through each being inversely as their resistances), and through these two branches it comes back to the − brush B and into the armature.

To find the Internal Resistance of a Shunt Dynamo.

In finding the resistance of a series dynamo it is not necessary to know the resistance of the armature and field magnets separately, as the internal resistance consists of the resistance of the two in series. In the case of the shunt machine, however, we *do* require to know the resistance of the armature and

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* Mr. Rimington is unable to continue his assistance with these articles, which will therefore be completed by Mr. Crawley.—ED. *E.*

† Particularly iron "tools"; also bringing an iron or sheet tin oil can too near the armature should be avoided.

field magnets separately, as the total resistance of a circuit worked by a shunt dynamo is the resistance of the armature plus the joint resistance of the external circuit and the field magnets. Fig. 24 will perhaps show this better than the former one did.

Here the resistance of the circuit is $A+\frac{BP}{B+P}$, B being the resistance of the field magnets.

To measure A, connect the wires from the bridge box to the terminals T and $T_{\prime}$, having previously disconnected one end of the field magnet wire from one of the terminals or brushes to which it is attached.

To measure the field magnet resistance, join the field magnet wire again to the terminal or brush from which it was discon-

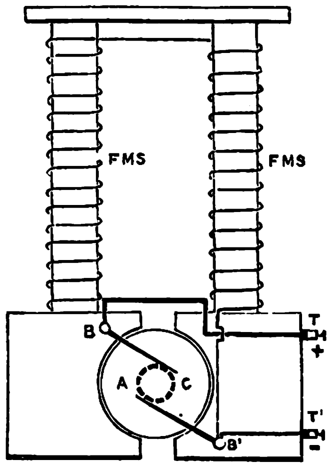

Fig. 22.—Shunt Dynamo.

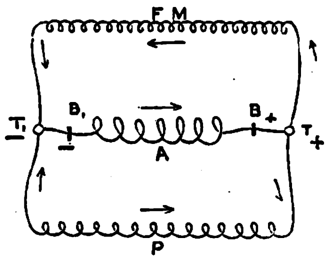

Fig. 23.—Extended Shunt Dynamo Circuit.

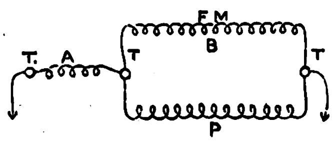

Fig. 24.

nected, and take one or both brushes off the collector or commutator; this will give the resistance of the field magnets.

Another method of finding these resistances without having to disconnect the field magnet wire is as follows:—

Firstly. Take the resistance of the machine through the terminals, with the brushes touching the collector; this will give us the joint resistance of the armature and field magnets, or $\frac{AB}{A+B}=m.$

Secondly. Take the brushes off the collector, and find the resistance as before; this will be the resistance of the field magnets, or B.

Then $$A=\frac{Bm}{B-m}$$

These resistances should be found in the same manner as was described for the series dynamo.

Suppose we are taking the measurements of a shunt dynamo, and we find the resistance of our lead wires from the bridge = ·004 ohms.

m + resistance of lead wires = ·3709 ohm.
B + „ „ „ = 4·464 ohms,
therefore m = ·3708 − ·004 = ·3668 ohm,
and B = 4·464 − ·004 = 4·46 ohms

then $$A=\frac{4{\cdot}46\times{\cdot}3668}{4{\cdot}46-{\cdot}3668}={\cdot}3996 \text{ ohm.}$$

Suppose, now, we run this machine through an external resistance of 1 ohm.

Then the total resistance in the circuit

$$={\cdot}3996+\frac{4{\cdot}46\times 1}{4{\cdot}46+1}=1{\cdot}2168 \text{ ohm.}$$

And if the total E.M.F. produced by the machine were 50 volts, the current flowing in the armature would be

$$\frac{50}{1{\cdot}2164}=41{\cdot}1 \text{ amperes,}$$

that in the external circuit

$$=41{\cdot}1\times\frac{4{\cdot}46}{4{\cdot}46+1}=33{\cdot}55 \text{ amperes,}$$

that round the field magnets

$$=41{\cdot}1\times\frac{1}{4{\cdot}46+1}=7{\cdot}55 \text{ amperes.}$$

Let in a shunt dynamo

A = resistance of the armature,	a = current in same.
B = „ „ field magnets,	b = „ „
P = „ „ external circuit,	p = „ „
E = total E.M.F.	e = terminal E.M.F.

As the current is generated in the armature, and when it leaves the brushes divides, part going round the field magnets and part through the external circuit, the current flowing through the armature is equal to the sum of the currents in the field magnets and external circuit, or $a=b+p$.

As it would be inconvenient to have to measure a or b we must find a and b in terms of p.

We have by Ohm's law

$$b=\frac{e}{B} \quad \text{and} \quad p=\frac{e}{P};$$

therefore $$a=\frac{e}{B}+\frac{e}{P}=\frac{e\,(P+B)}{BP}=\frac{p\,(P+B)}{B}.$$

This last equation gives us the current through the armature in terms of the current in the external circuit and the external and field magnet resistances.

A more convenient expression is

$$a=\frac{e}{B}+p,$$

p, the current in the external circuit, being easily obtained by means of an ammeter or other current measurer placed in that circuit, and e the terminal E.M.F. being obtained by a voltmeter attached to the terminals of the dynamo, as in the case of the series machine.

To obtain the total E.M.F. of the machine observe as before the terminal E.M.F. and current in the external circuit, then

$$E=e+aA=e+A\left(\frac{e}{B}+p\right)$$
$$=\frac{e\,(A+B)+ABp}{B}.$$

While the series dynamo gives its greatest E.M.F. and current when short circuited, the shunt, on the other hand, gives a very small E.M.F. and current when thus treated, as the small current generated by the residual magnetism of the field

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magnets all goes through the short circuit instead of round the field magnet coils.

Again, while a series dynamo gives practically no E.M.F. when on open circuit (*i.e.*, when the external resistance is infinite), a shunt dynamo gives its greatest E.M.F. in this condition. On this account a shunt machine should be short-circuited before it is switched on to a circuit of incandescent lamps, and then the short circuit taken off; or a resistance may be put into the lamp circuit sufficient to prevent the extra high E.M.F., derived from the machine running on open circuit, from making the lamps light up above their normal candle-power at the instant the machine is first switched on. Of course this resistance can be cut out immediately the machine is once on to the lamps.

The shunt machine is exceedingly useful where we have a varying external resistance, such as a number of incandescent lamps arranged in parallel arc, because the greater the external resistance the larger is the current round the field magnets in proportion to the current in the external circuit. Thus, with a shunt dynamo, as the number of lamps in parallel circuit is reduced by some of them being switched off, the terminal E.M.F. will increase. To keep this constant either the speed must be diminished, or, as is more usually done, resistance must be added to the field magnet circuit by means of a large resistance box, which is kept in series with the field magnets, so that more or less resistance can be added as required. One end of the field magnet wire is disconnected from the brush or terminal to which it is attached, and connected to one terminal of the resistance box, while the other terminal of the latter is connected to the brush or terminal of the dynamo, from which the field magnet wire was disconnected.

(TO BE CONTINUED.)

OLD CABLE STORIES RETOLD.—V.

BY F. C. WEBB.

THE CAGLIARI, MALTA, AND CORFU CABLES.

I ended my last article on the Atlantic Expedition of 1857 rather abruptly. I cannot help adding a few general remarks here. First, as regards the melting of the gutta percha at East Greenwich, it seems to me this never should have been allowed to take place. That a cable exposed to the rays of the sun ran considerable risk was so well known to me that I always, when landing cable at Lowestoft, covered it with a thick layer of hay, and had water pumped over it to keep the hay wet and cool by evaporation, and this work of pumping water over the hay was the only work carried on by our men on Sundays when in harbour. But there was another danger which the Atlantic cable incurred. The cable was passed through tanks of hot Stockholm tar; these tanks were heated by jets of gas under them. On my first visit to Messrs. Glass and Elliot's yard I arrived there at dinner hour, and found the cable leading from some six or seven machines, which were stopped, still in the tar tanks, and although the gas was turned down the tanks were quite hot to the hand, and must have been at a temperature considerably above blood heat. I was greatly astonished, and wrote to Mr. Bright, and received a note thanking me for the information, and saying it should be attended to. Who was responsible for the hot tar tanks, or the exposure of the cable to the sun? Was it the contractors or the company?

As regards the paying-out gear, it was designed by Mr. Bright and Mr. De Bergue, and I was told, on commencing to criticise the drawings, that nothing could be altered except the size of the V sheaves. That machine, although it was very ingenious in some respects, has never been used since, and it was an entire departure from what had been previously used. Indeed, the machine made for the 1858 expedition (which consisted of two independent drums with four or five V scores on each) has never been repeated. A return has been made to the drum and knife machine as used on the earlier cables, in some cases, it is true, with the "Appold" (or rather "Amos") brake, and in some cases with the ordinary brake straps arranged in various ways as regards the manner in which the strap is attached to the lever or is attached to the frame. But this subject could not be discussed without diagrams.

Passing on to history, or rather personal experience, the Atlantic Company had to reduce expenses, and as I had only an agreement which expired with the failure of the 1857 expedition, whilst the other three engineers had agreements which bound the company to keep them on till the completion of the cable, I had to look out for other work, and was engaged by Messrs. Newall and Co., who had engaged to lay the Cagliari, Malta, and Corfu cables, and had also to complete a four-conductor cable which they had attempted to lay between Bona (in Algeria) and Chia Bay near Cape Spartivento, the extreme southern point of the Island of Sardinia. The cable had been laid to within about 15 miles of Chia, when they ran short of four-conductor cable. They therefore spliced on some 10 miles of single wire cable which they had on board, and paid out till that ran short, and the end was let go a few miles from Cape Spartivento.

On October 21st, 1857, I started for Marseilles with Mr. Newall, and arrived there on the 23rd. The Liverpool steam tug "Blazer" (Captain Parry) was there, and the brake, 8ft. in diameter, was being fitted on the quarter deck. There was a length of 20 miles of four-conductor cable in a circular wooden structure in her hold, with proper cone and rings. We went on board on the evening of the 24th, and were about to start when there was a delay caused by a young Frenchman, who had to receive payment for the coal which had just been placed on board. Mr. Newall had naturally drawn a bill on his own firm for the amount of the coal bill, but the young Frenchman wanted, I suppose, for some particular personal profit of his own, to get a part of the sum paid in gold, and began by asking for a portion of the payment in gold. This was refused. He then began lowering his terms as regards the amount of gold, but in proportion as his terms lowered, his temper, or pretence of temper, increased. When he had got down to about £75 in gold, he was stamping about the cabin. I was translating the conversation between him and Mr. Newall, who was reclining on a sofa. At last the Frenchman began the trial of taunts. "*Comment,*" he said, "*des gen-tel-mans, voyageant comme vous, vous n'avez pas même cinquante livres en or.*" I translated this. "I wish I had him down a coal mine in the north," said Mr. Newall, *sotto voce*, and stroking his beard to keep his temper. I am afraid there would have been very little left of the Frenchman if Mr. Newall had had his wish. The little Frenchman, finding even his final grand taunt useless, gradually subsided, and carried away his bill, which, it is almost needless to remark, was his full and proper payment, and indeed it was not likely that Mr. Newall would use the £150 in gold he had provided on board for petty expenses at hotels, boats, &c., in paying coal bills. To carry gold enough to pay coal bills in telegraph expeditions would nearly sink the ship.

We went over to Bona, arriving on the 27th, and left there one of Messrs. Siemens's staff, with an induction coil instrument to speak to us when we hooked the cable off Spartivento. We started back same night for Spartivento, and arrived there on morning of 28th, and dredged without success for the cable. We had no picking up gear of any kind and no bow sheave, but I rigged up a temporary bow sheave. The next day (29th) we grappled again, got cable one mile from end, hove it up, cut it, and buoyed the short piece, and then hauled in the other nine miles by hand, came to four conductor cable, and made splice during night on to cable on board. The next morning (30th) we paid out towards shore, and landed the end.

I landed to bathe for the first time in Italian waters, and I was all alone. I was always devotedly fond of Italian opera, and seeing a strange gentleman, with long black moustache and piercing black eyes (who I soon knew afterwards as the Chevalier Franchesi, in charge of the telegraph) advancing towards me on the sea beach, I felt that now or never was the time to make use of some of the phrases I had gathered from the recitatives and duets in Italian operas. Taking my cap off and bowing in as near

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approach as I could to the exquisitely graceful bows I had seen the late Signor Mario make to various Queens and Kings in "The Huguenots," "Favorita," &c., I began boldly with "Salute Signore." "Aha! parlate Italiano," said Signor Franchesi delighted, and he launched forth in the purest Italian—for he was of an old Milanese family—a torrent of the "soft bastard Latin" that made me ignominiously cry for quarter by asking, "Vous parlez Français Monsieur?" and I had to take to that useful language for the rest of our acquaintance. But I was intent on recognising anything I could in the way of Italian that I was at all familiar with, and I can well recollect that the only words that struck me as familiar were when Signor Franchesi, seated before a double-needle instrument in the open air with a coloured handkerchief over his head to keep away the mosquitoes, and trying to speak to Cagliari with a failing battery, suddenly exclaimed, "Sacrrremento!! mi manca la pila." I was at once reminded of "Mi manca la voce!" in "Semiramide," and reflected on the difference in the situation, and what would have been the effect on the audience if that energetic "Sacrrremento!" had prefaced the words in the celebrated quartet?

On the 31st we left for Cagliari, where Messrs. Newall's ship "Elba," with the cable to be laid between Cagliari, Malta, and Corfu was to meet us. We arrived there in the middle of the night, landed, and were making our way quietly up the solitary streets, when we were fetched back by gendarmes, and placed in a kind of cage, like wild beasts, on account of sanitary ideas, until the captain was fetched from the ship, and certain papers were examined. We were at last released, and then had to knock for about an hour at the Hotel della Concordia to gain admittance, as nobody was expected at that hour from anywhere.

(TO BE CONTINUED.)

ON GLOBE LIGHTNING.*

BY M. GASTON PLANTÉ.

Some years ago I described, under the title of "The Moving Electric Spark," a particular phenomenon produced by the

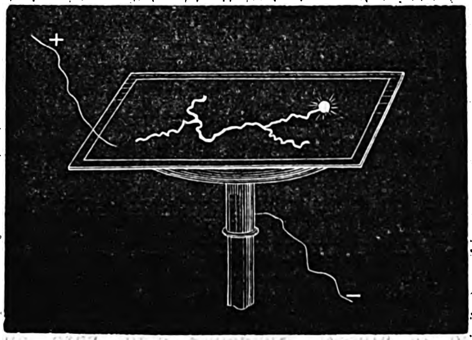


FIG. 1.

passage of an electric current of high tension. If a condenser, with very thin mica plate, be connected by its two armatures with the electrodes of a secondary battery of 800 couples, the condenser can be pierced, owing to the high tension of the current, and as under these conditions the quantity of current is far greater than with a source of static electricity, the effect is not confined to the production of a crackling spark; a small incandescent globule is formed, owing to the fusion of the matter of the condenser itself, and this globe moves slowly at the surface, following the points where the insulating plate which separates the armatures offers less resistance, and describing a most capriciously sinuous course (Fig. 1).

The experiment can be made to last for one or two minutes; it only ceases when the battery is so far discharged that the globule can no longer be maintained in a molten state between the two armatures. The slow motion of this little globule is

* From the *Comptes Rendus* for August 11.

accompanied by a strong crackling noise, and when the condenser is made to stick to the surface of a plate of hard caoutchouc a shrill and strident noise is heard, something like that produced by a fast revolving saw when cutting metal. The condenser is at the same time sawn and cut open over the whole course followed by the sparking globule. I have pointed out the analogy between these effects and those produced by globe lightning. Still better to imitate the conditions under which the natural phenomenon is produced, I lately increased the tension of the dynamical source of electricity, and used the current from a secondary battery of 1,600 couples, the electromotive force of which during the first moments of discharge was about 4,000 volts. Suppressing, on the other hand, the plate of mica and the metal armatures, since there are in the atmosphere but masses of air and vapour of water, I operated simply with the damp electrified surfaces separated by a layer of air. These damp surfaces were composed of pads or discs of filter paper moistened with distilled water.

When these were connected with the poles of the battery, a small ball of fire appeared which ran from one side to the other between the two surfaces, and appeared and disappeared spontaneously at intervals during several minutes. As the battery did not discharge so rapidly as with the metal armatures, the experiment lasted longer. The intervals were due to the fact that, when the globule of fire had dried different points of the damp surfaces, owing to the heating effect it produced, and had driven off the aqueous vapour whose presence diminished the resistance of the interval between the surfaces, the current was interrupted at these points; but the effect then reappeared at other points which remained damp, and so on to the end. These experiments appear to me to confirm the explanations which I have already offered with regard to globe lightning,* and I think I may conclude to-day with greater certainty that globe lightning is a slow and partial discharge, either direct or by induction (*influence*) of the electricity of thunder clouds, when this electricity abounds in exceptional quantities, and the cloud itself, or the damp column of strongly electrified air which forms so to speak the electrode of it, is in close proximity to the ground, even so close as to all but touch it, or to be separated by a thin layer

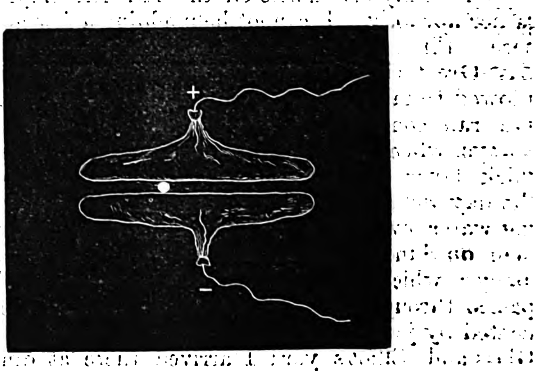


FIG. 2.

of insulating air. Under these conditions the electric flow, by reason of its abundance, or more exactly the ponderable matter which it traverses, collects, as in the experiments I have just described, in the form of a globe of fire. It is in some sort an electric egg, without a glass envelope, which is formed with the rarefied and incandescent elements of the air and the vapour of water. This globe of lightning does not constitute a kind of bomb charged with electricity; it is not dangerous of itself, as the curious stories of Babinet and different observers prove; for the least current of air is sufficient to displace it, as in the above experiments. A light breath on the globule will cause it to disappear for the moment, but its presence is none the less formidable, for it draws electricity from the thundercloud, with which it is connected in a hidden though sometimes visible manner, like waterspouts, and indicates the place where the discharge will take place.

* *Comptes Rendus*, 3rd May, 1875; 21st August, 1876; 1st October, 1877; and 19th August, 1878.

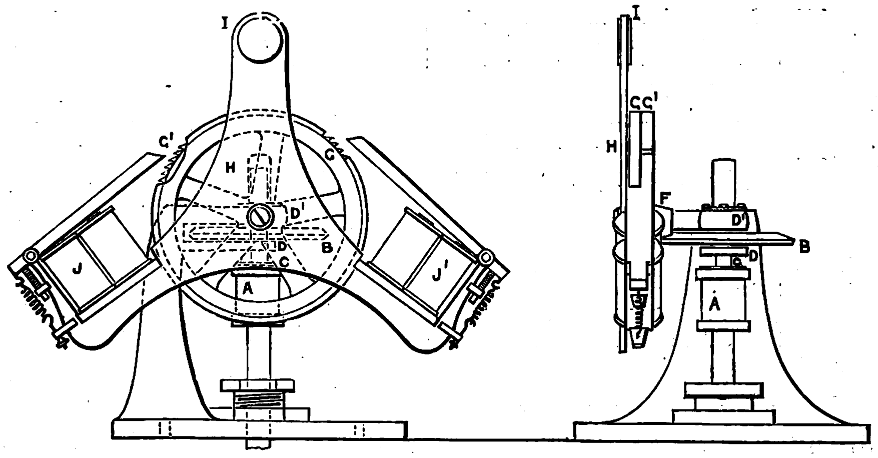
If the layer of air which separates the cloud from the earth is not traversed, the globe of fire disappears without noise, as has often been observed; or if a portion of the thundercloud is depressed towards the earth or other point, lightning may fall later on, at the same time that the globe disappears. But, if the layer of air is pierced, the natural result is, at the same point where the globe appeared, a stroke of lightning accompanied by thunder, proceeding not from the small quantity of electricity enclosed in the small mass of rarefied and luminous air which forms the globe, but from the sharp discharge of all the electricity, or a large portion thereof, contained in the thundercloud. The slow and capricious movement of these lightning globes is explained, like that of the globules of electric fire produced in the above experiments, by the variations in the resistance of the layer of air which separates them from the earth, and by the natural tendency of the electric discharge to seek the line of least resistance in its passage to earth.

Regarding the globes of fire which sometimes appear in the midst of the clouds themselves, and of which Arago has cited several examples, the experiment cited above (Fig. 2) gives an exact representation, although on a reduced scale, and it is sufficient to see it to understand the natural phenomenon.

In this way can be explained the various effects of globe lightning or thunder balls, which seemed to be an enigma so long as comparison could only be made with the effects produced by apparatus generating static electricity, where the quantity of electricity at work is too small to present analogous phenomena, but which become, on the contrary, easy of comprehension when we compare them with the effects produced by a source of dynamic electricity uniting at once quantity and tension.

THE PORTE-MANVILLE ELECTRIC GOVERNOR.

We have more than once pointed out the necessity of having engines which will govern when employed for electric light purposes. The aim of engineers is to obtain engines that shall run with absolute constancy, and when change is necessary the action to be dead beat. So far as as we know no governer yet in use is dead beat. The one herewith illustrated seems, however, to go a long way towards solving the problem, and its use up to the present supports the claims of the inventors. Its action will be readily understood from the following:—



Porte-Manville Governor.

The bevel-wheel B runs between two collars, D and D^1, being thus free to revolve without vertical motion; the boss of the wheel is tapped, and has a threaded spindle, C, running through it; part of the spindle is cut square, and passes through a square hole in the collar D, which prevents the spindle turning with the wheel, and only allows it to be screwed up and down. It will thus be seen that when the bevel-wheel turns the valve is either opened or shut.

Movement is given to the bevel-wheel by a spur wheel, to which are attached two ratchet wheels, G G^1, with their teeth cut in opposite directions.

Upon the same spindle as the spur and ratchet wheels, but unattached to them, is the three-armed carriage H, which is kept oscillating about its centre by the upper arm I being attached to a reciprocating part of the engine.

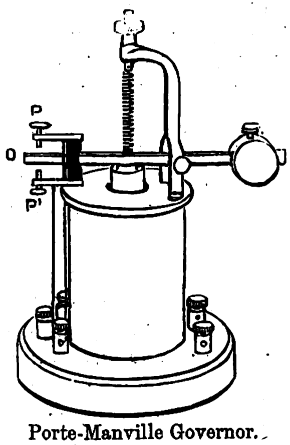
On the other two arms of the carriage are electro-magnets J and J^1, with their armatures prolonged into pawls, the pawl of one magnet being over one ratchet and the pawl of the other magnet over the other ratchet.

If, now, a current is sent over the left-hand magnet, its armature is attached, and engages its own ratchet wheel, which turns the whole system in the direction that raises the valve. If the current passes over the other magnet, the reverse takes place, and the valve closes.

The governor may be controlled in two ways:—

1. If it is desired to keep the speed of the machine constant a tachometer, K, is used, on the glass of which is mounted two contact plates, L L^1, separated by a very small division which is placed opposite the speed on the tachometer dial at which the machinery is to run. If now the speed drops at all the needle comes in contact with the lower plate, sends the current over the magnet that opens the valve until the machinery runs again at the proper speed, when the needle regains its position between the two plates, and the valve is left untouched until either the pressure of steam or the work again alters; the reverse takes place should the speed of the machinery rise.

2. If it is desired to keep the E.M.F. or current constant, a solenoid relay, M, is used either in shunt or in series with the main, the contact arm O is adjusted with the proper current to keep midway between the contacts P P^1. Should the current increase the solenoid is sucked down, makes contact with the lower point, and the current is sent through that electro-magnet which cuts off steam. When the current decreases the reverse takes place.



Porte-Manville Governor.

It will be noticed that with the Porte-Manville governor no action takes place unless there be a variation in the governing forces, and is consequently dead beat.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes ... 357
The Induction of Currents in Cores. By Oliver Heaviside. (Continued.) ... 362
The Elements of Electric Light Engineering. By C. W. S. Crawley. (Continued.) Illus. 363
Old Cable Stories Retold.—V. By F. C. Webb ... 365
On Globe Lightning. By M. Gaston Planté. Illustrated. 366
The Porte-Manville Electric Governor. Illustrated ... 367
International Inventions Exhibition ... 368
Correspondence ... 369
Siemens' Apparatus for Testing the Resistance of Lightning Rods. Illustrated ... 369
Dr. Joule ... 370
A Telegrapher's Practical Joke ... 372
The British Association at Montreal ... 373
The Telephone and the Post Office ... 378
Companies' Meetings— Pilsen, Joel, and General Electric Light Company ... 379
Companies' Share List ... 380

INTERNATIONAL INVENTIONS EXHIBITION.

Whatever else may be said for the Health Exhibition it has certainly contributed very largely to healthy enjoyment during a season when indoor recreation has been far from healthy or enjoyable. Its success in partially emptying all London theatres while the thermometer stood at 85° cannot be regarded otherwise than as an unmixed boon, both to the few who have attended them and the many who have gone to the Healtheries instead. Such indeed—partly owing to an almost unprecedented summer, partly to the novel attractions of the Exhibition itself—has been the extraordinary run upon South Kensington that it will surprise no one to hear of a fresh experiment in the same direction to be tried next year. The Commissioners are hardly likely to fail, and are almost sure to succeed, whatever they may hit upon in the way of an excuse for promenading the magnificent grounds and buildings of the Royal Horticultural Gardens. But the Prospectus just issued for next year is attractive in itself, more so than that which has formed the nominal object of the exhibition this year. In point of popular interest an Exhibition of Inventions from all parts of the world ought to have the advantage over the dry and too generally unattractive subject of Health. In this wicked world great reward always awaits him who invents a new pleasure. The Exhibition Commissioners have invented one already, and if they are mindful to include it among the inventions next year there will be no falling off in public acknowledgment.

The Exhibition of 1885 is one which will afford greater openings for the display of apparatus and appliances in which our readers are interested than has been possible at any former exhibition at South Kensington. It is to include inventions of all kinds, not previously shown there, introduced since the year 1862; and the group devoted to electrical appliances is as comprehensive as could be desired, besides the places they will find under the heads of Railway Signalling, Illumination, and Philosophical Instruments. The Electrical group is divided into twelve classes, comprising Generators, Conductors, Testing and Measuring apparatus (Telegraphic and Telephonic), Electric Lighting, Electro-Metallurgy and Electro-Chemistry, Distribution and Utilisation of Power, Electric Signalling, Lightning Conductors, Electro-Medical apparatus, Electrolytic processes, and, lastly, Electro-Thermic apparatus. What a wide field for inventive exhibitors this grouping offers will be obvious at a glance, covering as it does the whole area of telegraphic enterprise, from submarine cables and the apparatus for laying them to the construction of telephone lines and the instruments for working them. And in respect to Electric Lighting, the choice does not seem to be narrowed by the condition above alluded to limiting the exhibits to objects not previously shown at the three preceding exhibitions unless under "exceptional circumstances." We should suppose that the lighting systems employed for illuminating those exhibitions would be regarded as "exceptional" adjuncts, not as actual exhibits. For the other classes we have named, the scope is equally judicious and extensive. Some unusual regulations are laid down with regard to space, as the Commissioners appear to be apprehensive of more applicants than they can find room for; but this will not materially affect the display of electrical appliances in their entirety.

Some good practical reason has no doubt induced the Commissioners to draw a line for Inventions at a particular year. "Division I. (Inventions)," says the prospectus, "will be devoted to illustrations of apparatus, appliances, processes, and products invented or brought into use since 1862." The period between that time and 1885 is spoken of as "a quarter of a century," which is not strictly the fact; possibly the limitation has something to do with the Patent Laws, for among the regulations we find one stating that "untried and unpatented inventions will not be accepted unless recommended by a competent authority." There are many valuable and tried inventions that have not been patented even since 1862. Probably what is meant is that when an alleged invention has neither been tried nor patented it will have to come with good credentials; which is quite proper, although on the other hand we demur to the implied inference that all inventions patented have therefore been "tried," especially under the harum-scarum system which now goes by the name of Patent Law.

But for the regulation just referred to, we think that a highly instructive historical group might have been got together of inventions, dating from remote ages down to the mysterious 1862. Models are recommended by the Commissioners in preference to actual machinery with a view to economising space, and our historic group would have lent itself admirably to illustration by model. Perhaps, however, nobody cares about ancient inventions sufficiently to reconstruct them in miniature for our edification. Or, perhaps, there are some people to whom such generosity to our forefathers would prove unwelcome and even painful. Still, for the curious observer a collection of ancient inventions which have been invented over and over again "since 1862"—if the Commissioners could only find room for them—would have been a striking addition to any Exhibition professedly devoted to International Invention. We notice that Division II. (Music) is to have its Historic Collection; probably for the sufficient reason that musical invention would be very inade-

quately represented by the productions of modern times. In this division the Commissioners extend their view back to "examples of Musical Instruments of a date not earlier than the commencement of the present century." But, as the tin whistle and barrel organ would probably exhaust this Class, there is also to be the Historic Class. For similar reasons we should have liked to have seen a Historic Class for Inventions.

In the main the exhibition, apart from its musical feature, will be confined to inventions which are the outcome of scientific discovery. Electricians and Electrical Engineers will have no fault to find with this restriction, as the science of Electricity has contributed probably more than any other branch of investigation in modern times to the multiplication of inventions and their application "to the purposes of daily life." Electrical inventors—and their name is legion—should lose no time in availing themselves of this opportunity, as applications for space must reach the Secretary by 15th September. Commissioners of Foreign Governments are being appointed, and it is hoped and expected there will be numerous applications from abroad. We trust that Englishmen will not prove to be behind their foreign competitors in ingenuity, especially as we are admitted to be ahead of them in scientific knowledge.

CORRESPONDENCE.

PRACTICAL TELEPHONY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Would you kindly state what subjects you think are necessary for a telephone inspector who wishes to make some progress in his profession.

I have been studying machine construction, mathematics, theoretical mechanics, and electricity, and am going to study telegraphy and chemistry.

Besides paying attention to his business and reading the electrical papers, do you think these are sufficient?

Is the telephone profession one you would recommend a youth to follow? Has it good prospects?

Your kind attention to this in your earliest issue will oblige not only myself but many others.—Yours, &c.,

Sandholes, Paisley, 19th August, 1884. WENDUR.

[Perhaps someone engaged in the work would answer our correspondent.—ED. *E.*]

THE AMALGAMATION OF ZINC.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: While fully appreciating all that poor Sturgeon has done for the allied sciences of electricity and magnetism, I am not prepared to admit that the use of amalgamated zinc in the voltaic battery was originated by him, as I find is stated in Dr. Joule's letter, on page 188 of *The Electrician* for July 5th, 1884. His writings and lectures tended no doubt to its general introduction, but the credit of its discovery belongs to another, as I have shown in my "History of Electric Telegraphy."

On page 218 of this work I say:—"The first mention of amalgamated zinc in voltaic arrangements occurs in Sir H. Davy's Bakerian lecture for 1826, in which he simply remarked that 'zinc in amalgamation with mercury is positive with respect to pure zinc,' without any allusion to the beneficial employment of it in the construction of batteries. Kemp, of Edinburgh, was the first to employ amalgamated zinc and copper in the regular construction of batteries. (*See* his papers in Jameson's *New Edinburgh Phil. Journal* for December, 1828."

In further support of my contention I beg to refer those interested in the question (1) to "Ronalds' Catalogue," p. 265, under heading Kemp; and (2) to Sturgeon's own "Annals of Electricity, &c.," Vol. I., pp. 81-8.

The first published observations of Sturgeon on this subject are, as stated on page 189 of your journal, contained in his "Experimental Researches in Electro-Magnetism, Galvanism, &c.," which appeared in 1830.

Owing to my distance from London this letter will be long in reaching you, and will in consequence lose much of its interest. Still, as I know you like to be accurate, I hope you will give it a place in your journal.—Yours, &c.,

J. J. FAHIE.

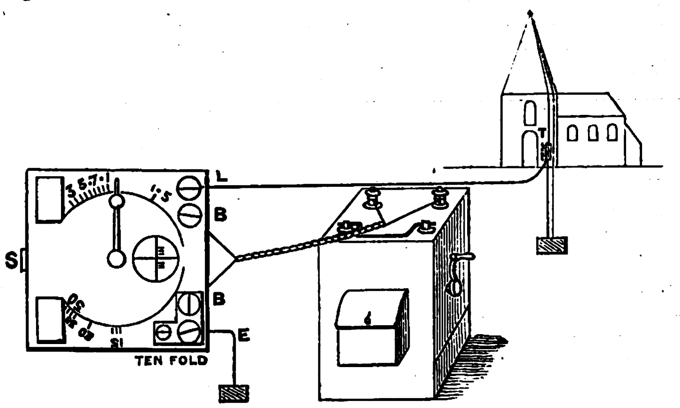
Teheran, Persia, July 29, 1884.

SIEMENS' APPARATUS FOR TESTING THE RESISTANCE OF LIGHTNING RODS.

The apparatus consists of a magneto-inductor contained in a wooden box, and a small bridge board sliding into a recess at the bottom of the box. To the latter are affixed a German silver ring, a pointer, which also acts as a battery key, a small galvanometer, four terminals marked L, B, B, E, and beneath the board a constant resistance.

It is advisable when erecting a lightning rod that a loose copper wire be connected to the point of same, running down parallel with it to the base; a connection may then be made to this which would save the trouble of climbing up to the point each time the lightning rod had to be tested.

For economy sake when erecting a lighting rod, two ropes having the same sectional area as the single rope intended to be fitted might be used, both of them being connected to the earth plate, and acting as a single conductor. One of the ropes could then have a connection screw fitted at the base T, so that it could be disconnected from earth for testing as required.



Siemens' Lightning Rod Testing Apparatus.

When a lightning rod is to be tested, terminal L has to be connected to the point of the rod or the loose wire below, terminal E to a reliable earth, and terminals B B to the inductor. Then, by turning the inductor handle and pressing down the pointer on the board, a current is sent through the bridge, and if a deflection be shown on the galvanometer, the pointer (still being pressed down) must be turned to the left or right until the needle stands at zero. The graduations round the ring have been so arranged that in this position the pointer will stand at the figure corresponding to the resistance in ohms of the lightning rod and its earth connection.

The board must be so turned before the test is made that the needle of the galvanometer swings freely and stands at zero, and it must be placed as far from the inductor as the leading wire supplied with the instrument will allow, that the galvanometer may not be affected by the magnetism of the magnets in the inductor. There is a small brass slide, S, at the back of the bridge board which by withdrawing sets the needle into action, and by pushing in lifts it off again. When measuring higher resistances the screw marked "ten-fold" must be taken out; the instrument will then measure ten-fold the resistances marked on it, *i.e.*, from 1 up to 500 ohms.

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DR. JOULE.

A short time ago we gave a short biography of Mr. Sturgeon from the "Centenary of Science in Manchester," issued by the Philosophical Society of Manchester, in commemoration of its hundredth anniversary. We now take from the same source the biographical notes on Dr. Joule, a man whom England is delighted to honour:—

"Almost concurrent with later chemical search on the constituents of matter we see an inquiry in physics, where also atoms have done full duty, and without which the existence of gases, for example, has been found to be difficult to conceive. The condition may be shortly described in a summary serving as an introduction to the works of the late Thomas Graham, Master of the Mint.

"'When we arrive at this point we pass to the next important stage, namely, the motion of gaseous molecules, if not of atoms, and the beginning of the attempt to define it precisely. The first definite ideas are by D. Bernouilli. They are explained in his "Hydrodynamics," which although published in Strasburg in 1738, were previously worked at when he was Professor in St. Petersburg.

"'D. Bernouilli says: "The chief peculiarities of fluids are these: first, they are heavy; second, they expand in all directions unless they are confined; and third, they allow themselves to be compressed more and more, according to the increased force applied." Speaking of a vessel of air with a weighted cover, and which he illustrates with a diagram, he says, "So the minute bodies, whilst they impinge on the cover E F, keep it up by their continually repeated strokes, and form an elastic fluid which expands itself when the weight is removed or diminished. We shall consider the corpuscles enclosed in the hollow of the cylinder as infinite in number, and when they occupy the space E C D F we shall say that they constitute the natural air."

"'Davy and Count Rumford entered the field when this theory of gaseous motion was forgotten, and inaugurated a new theory of heat founded on molecular activity. That heat is immaterial was no rare opinion last century, or since Lord Bacon spoke of it as "motus et nihil aliud." However, atomic motion ceased from the time of Rumford to be a vague idea. Davy spoke definitely when, without calling in the aid of repulsions, he supposed that in solids the particles are in a vibratory motion, the particles of the hottest bodies moving with greatest velocity and through the greatest space; that in fluids and elastic fluids, besides the vibratory motion which must be considered greatest in the last the particles have a motion round their own axes with different velocities, the particles of elastic fluids moving with the greatest quickness; and that in ethereal substances the particles move round their own axes and separate from each other, penetrating in right lines through space. Temperature may be conceived to depend on the velocity of the vibrations, increase of capacity on the motion being performed in greater space, &c.'

"This is evidently the work of Rumford and Bernouilli, with additions after passing later through an original and powerful mind.

"We may take the next step and go to Herapath. At p. 14, Vol. I., he says:—

"'*Theory of Gases.*—From these considerations it follows that if a number of small bodies be enclosed in any hollow body, and be continually impinging on one another and on the sides of the enclosing body, and if the motions of the bodies be conserved by an equivalent action in the sides of the containing body, then will these small bodies compose a medium, whose elastic force will be like that of air and other gaseous bodies; for if the bodies be exceedingly small, the medium might, like any æriform body, be compressed into a very small space; and yet if it had no other tendency than what would arise from the internal collision of its atoms, it would, if left to itself, extend to the occupation of a space of almost indefinite greatness. And its temperature remaining the same, its elasticity would also be greater when occupying a less, and less when occupying a greater space; for in a compressed state the number of atoms striking against a given portion of the containing vessel must be augmented, and the space in which the atoms have to move being less, their motions or periods must be shorter, and the number of them in a given time consequently greater; on both of which accounts the elasticity is greater the greater the compression. Besides, when other things are the same, the elastic force augments with an augmentation of temperature and diminishes with a diminution; for an increase of temperature, according to our theory, must necessarily be attended with an increase of velocity, and therefore with an increase in the number of collisions.'

"'Dr. Joule continued the subject, and introduced it into the region of experiment and observation, or, in other words, to the science of modern times. Joule might have added that the view he adopted is not only in accordance with the known laws of the elasticity of gases, but conforms to the ratio of the specific heats of gases. The mathematical development continued to make progress in the hands of Clausius, Clerk Maxwell, Holtzmann, and others, taking us to new fields, &c.'

"In 'Some Remarks on Heat and the Constitution of Elastic Fluids,' by J. P. Joule, F.R.S., &c., Mem. Lit. and Phil. Soc., Vol. IX., Second Series, p. 111, read October 3rd, 1848, we find:—

"'I have myself endeavoured to prove that a rotary motion such as that described by Sir H. Davy will account for the law of Boyle and Mariotte, and other phenomena presented by elastic fluids; nevertheless, since the hypothesis of Herapath—in which it is assumed that the particles of a gas are constantly flying about in every direction with great velocity, the pressure of the gas being owing to the impact of the particles against any surface presented to them—is somewhat simpler, I shall employ it in the following remarks on the constitution of elastic fluids; premising, however, that the hypothesis of a rotary motion accords equally well with the phenomena.

"'Let us suppose an envelope of the size and shape of a cubic foot to be filled with hydrogen gas, which, at 60° temperature and 30in. barometrical pressure, will weigh 36·927 grains. Further, let us suppose the above quantity to be divided into three equal and indefinitely small elastic particles, each weighing 12·309 grains; and further, that each of these particles vibrates between opposite sides of the cube, and maintains a uniform velocity except at the instant of impact. It is required to find the velocity at which each particle must move so as to produce the atmospherical pressure of 14,831,712 grains on each of the square sides of the cube. In the first place it is known that if a body moving with the velocity of $32\frac{1}{6}$ft. per second be opposed during one second by a pressure equal to its weight, its motion will be stopped, and that, if the pressure be continued one second longer, the particles will acquire the velocity of $32\frac{1}{6}$ft. per second in the contrary direction. At this velocity there will be $32\frac{1}{6}$ collisions of a particle of 12·309 grains against each side of the cubical vessel in every two seconds of time; and the pressure occasioned thereby will be $12{\cdot}309 \times 32\frac{1}{6} = 395{\cdot}938$ grains. Therefore, since it is manifest that the pressure will be proportional to the square of the velocity of the particles, we shall have for the velocity of the particles requisite to produce the pressure of 14,831,712 grains on each side of the cubical vessel,

$$v = v\left(\frac{14{,}831{,}712}{395{\cdot}938}\right)32\tfrac{1}{6} = 6{,}225\text{ft. per second.}$$

"'The above velocity will be found equal to produce the atmospheric pressure, whether the particles strike each other before they arrive at the sides of the cubical vessel, whether they strike the sides obliquely, and, thirdly, into whatever number of particles the 36·927 grains of hydrogen are divided.

"'If only one-half the weight of hydrogen, or 18·4635 grains, be enclosed in the cubical vessel, and the velocity of the particles be as before, 6,225ft. per second, the pressure will manifestly be only one-half of what it was previously; which shows that the law of Boyle and Mariotte flows naturally from the hypothesis.

"'The velocity above-named is that of hydrogen at the temperature of 60°; but we know that the pressure of an elastic fluid at 60° is to that at 32° as 519 is to 491. There-

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fore the velocity of the particles at 60° will be to that at 32° as $\sqrt{519}$, $\sqrt{491}$; which shows that the velocity at the freezing temperature of water is 6,055ft. per second.

"'In the above calculations it is supposed that the particles of hydrogen have no sensible magnitude, otherwise the velocity corresponding to the same pressure would be lessened.

"'Since the pressure of a gas increases with its temperature in arithmetical progression, and since the pressure is proportional to the square of the velocity of the particles, in other words, to their *vis viva*, it follows that the absolute temperature, pressure, and *vis viva* are proportional to one another, and that the zero of temperature is 491° below the freezing point of water. Further, the absolute heat of the gas, or in other words, its capacity, will be represented by the whole amount of *vis viva* at a given temperature. The specific heat may therefore be determined in the following simple manner:—

"'The velocity of the particles of hydrogen, at the temperature of 60°, has been stated to be 6,225ft. per second, a velocity equivalent to a fall from the perpendicular height of 602,342ft. The velocity at 61° will be 6,225 $\sqrt{\frac{520}{519}} = 6{,}230{\cdot}93$ft. per second, which is equivalent to a fall of 603,502ft. The difference between the above falls is 1,160ft., which is therefore the space through which 1lb. of pressure must operate upon each pound of hydrogen in order to elevate its temperature one degree. But our mechanical equivalent of heat shows that 770ft. is the altitude representing the force required to raise the temperature of water one degree; consequently the specific heat of hydrogen will be $\frac{1160}{770} = 1{\cdot}506$, calling that of water unity.

"'The specific heats of other gases will be easily deduced from that of hydrogen; for the whole *vis viva* and capacity of equal bulks of the various gases will be equal to one another, and the velocity of the particles will be inversely as the square root of the specific gravity. Hence the specific heat will be inversely proportional to the specific gravity, a law which has been arrived at experimentally by De la Rive and Marcet.

"'In the following table I have placed the specific heats of various gases, determined in the above manner, in juxtaposition with the experimental results of Delaroche and Berard reduced to constant volume:—

	Experimental specific heat.		Theoretical specific heat.
Hydrogen	2·352	...	1·506
Oxygen	0·168	...	0·094
Nitrogen	0·195	...	0·107
Carbonic oxide	0·158	...	0·068

"'The experimental results of Delaroche and Berard are invariably higher than those demanded by the hypothesis. But it must be observed that the experiments of Delaroche and Berard, though considered the best that have hitherto been made, differ considerably from those of other philosophers. I believe, however, that the investigation undertaken by M. V. Regnault, for the French Government, will embrace the important subject of the capacity of bodies for heat, and that we may shortly expect a new series of determinations of the specific heat of gases, characterised by all the accuracy for which that distinguished philosopher is so justly famous. Till then, perhaps, it will be better to delay any further modifications of the dynamical theory, by which its deductions may be made to correspond more closely with the results of experiment.'

"We have thus got to the motion of atoms, but the result of this motion was also taken up by Joule, and we give him without difficulty the honour of showing its relations first in one very important direction, namely, heat. We have the pleasure of knowing that he went still further, and showed that whilst the heat itself resulted in force, that force had a definite limit, and could be estimated by the amount of chemical action or by the combinations taking place between the elements. In other words, he showed the connection between chemical action, electricity, heat, and mechanical force. The long train of papers on this subject written by Dr. Joule would astonish many who receive his results in a few lines, and are satisfied with their simplicity; but it would also be a very simple thing if, after living to maturity in a pit, with artificial light only, we were to come up and see the sun. How simply we should then get light—no candle used, no wax, no oil, no paraffin; the sun laughs at all our methods of illumination, and we, too, may laugh at ourselves when we think how short was our view in the direction indicated before Dr. Joule discovered the mechanical equivalent of heat. To show the fullest early form in which the author approached the subject we quote farther on. (*See* Mem. of the Lit. and Phil. Soc. of Manchester, Vol. VII., Second Series, pp. 103, 104, and 110.) We shall further quote a paper read January 24, 1843, his 20th paper on heat, electricity, and magnetism, though still a youth.

"When speaking of Dr. Joule we must not forget to put before ourselves clearly the position taken up by Faraday in the development of measurable quantity, a position which is gained by the vantage ground of the atomic theory, and stands between that of Dalton's and Joule's, to whose wider generalisations it tended. In his 'Experimental Researches in Electricity,' § 704 (ed. 1839), we find one of his papers read in January, 1834: 'I have already said, when engaged in reducing common and voltaic electricity to one standard of measurement, and, again, when introducing my theory of electro-chemical decomposition, that the chemical decomposing action of a current is constant for a constant quantity of electricity, notwithstanding the greatest variation in its sources, in its intensity, in the size of the electrodes used, in the nature of the conductors (or non-conductors, 307) through which it passes, or in other circumstances.'

"'§ 705. I endeavoured upon this law to construct an instrument which should measure out the electricity passing through it, and which, being interposed in the course of the current used, should serve at pleasure either as a *comparative standard* of effect or as a *positive measure* of the subtle agent.'

"§ 706. . . . 'Water therefore, acidulated by sulphuric acid, is the substance I shall generally refer to, although it may become expedient in peculiar cases or forms of experiment to use other bodies.' In § 843 it is said, 'I expect to find in some salts, as the acetate of mercury and zinc, solutions favourable for this use.'

"In § 866, speaking of the decomposition of water, he says, 'For an equivalent of zinc oxidised an equivalent of water must be decomposed.'

"'§ 918. All the facts show us that that power commonly called chemical affinity can be communicated to a distance through the metals and certain forms of carbon; that the electric current is only another form of the forces of chemical affinity; that its power is in proportion to the chemical affinities producing it; that when it is deficient in force it may be helped by calling in chemical aid, the want in the former being made up by an equivalent of the latter; that, in other words, "*the forces termed chemical affinity and electricity are one and the same.*"'

"That equivalents exist is no proof of oneness, but we see here great progress made by Faraday in the consideration of the unity of power and the relation of important forms of power.

"We shall quote here some of Joule's early papers.

"*On the Heat Evolved during the Electrolysis of Water.* January 26, 1843. By James Prescott Joule. Vol. VII., Second Series, *Memoirs* of the Literary and Philosophical Society of Manchester, pp. 101, 103, 104, 110.

"'1st. In an electrolytic cell, there are three distinct obstacles to the voltaic current. The first is resistance to conduction, the second is resistance to electrolysis without chemical change, arising simply from the presence of chemical repulsion, and the third is resistance to electrolysis accompanied by chemical changes.

"'2nd. By the first of these (the resistance to conduction) heat is evolved exactly as it is by a wire, according to the resistance and the square of the current; and it is thus that a part of the heat belonging to the chemical actions of the battery is evolved. By the second, a reaction on the intensity of the battery occurs, and wherever it exists heat is evolved

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exactly equivalent to the loss of heating power in the battery arising from its diminished intensity. But the third resistance differs from the second, inasmuch as the heat due to its reaction is rendered latent and is thus lost by the circuit.

"'3rd. Hence it is that, however we arrange the voltaic apparatus, and whatever cells of electrolysis we include in the circuit, the whole caloric of the circuit is exactly accounted for by the whole of the chemical changes.

"'4th. As we discovered by Faraday, the quantity of current electricity depends upon the number of atoms which suffer electrolysis in each cell, and the intensity depends upon the sum of chemical affinities. Now both the mechanical and heating powers of a current are (*per* equivalent of the electrolysis in any one of the battery cells) proportional to its intensity. Therefore the mechanical and heating powers of a current are proportional to each other.

"'5th. The magnetic electrical machine enables us to convert power into heat, by means of the electric currents which are induced by it. And I have little doubt that by interposing an electro-magnetic engine in the circuit of a battery, a diminution of the heat evolved *per* equivalent of chemical change would be the consequence, and this in proportion to the mechanical power obtained.*

"'I have shown also that the *modus operandi* is resistance to conduction.

"'There are many phenomena which cannot be accounted for by the theory which recognises heat as a substance; and there are several, which though sometimes adduced as triumphant objections to the other theory, tend, when rightly considered, only to confirm it. The heat of fluidity may very naturally be regarded as the momentum, or mechanical force necessary to overcome the aggregation of particles in the solid state. The heat of vaporisation may be regarded, partly as the mechanical force requisite to overcome the aggregated condition of atoms in the fluid state, and partly as the force requisite to overcome atmospheric pressure. Again, the heat of combination is only the manifestation, in another form, of the mechanical force with which atoms combine; on the other hand, the phenomena of electrolysis by the voltaic battery give us positive proof that the mechanical force of the current requisite to procure the decomposition of an electrolyte is the equivalent of the heat due to the recombination of the elements. *Thus it appears that electricity is a grand agent for conveying heat and the ordinary forms of mechanical power into one another.*'

"'*On a New Method of Ascertaining the Specific Heat of Bodies.* Read December 2, 1845. *Memoirs* of Philosophical Society of Manchester, Vol. VII., Second Series, p. 562.

"'When any body, capable of conducting the voltaic electricity, is placed in the circuit of a battery, the quantity of heat evolved by it in a given time is proportional to its resistance to conduction and the square of the quantity of transmitted electricity. Consequently, if a wire traversed by a voltaic current be made to communicate to any body the heat which it evolves, the capacity for heat of that body and the wire taken together will be directly proportional to the square of the quantity of electricity transmitted in a given time to the resistance of the wire and to the time, and inversely proportional to the increase of temperature of the body. Hence we derive the general equation,

$$y = \frac{Cc^2rt}{h} \quad . \; . \; . \; . \; . \; . \; . \; . \quad (1)$$

where y is put for the capacity, c for the voltaic current, r for the resistance of the wire, t for the time, and h for the increase of temperature.

"'If we make the time and the resistance of the wire constant, the above equation becomes simplified to

$$y = \frac{Cc^2}{h} \quad . \; . \; . \; . \; . \; . \; . \; . \quad (2)$$

"'If the current and time are constant, we have

$$y = \frac{Cr}{h} \quad . \; . \; . \; . \; . \; . \; . \; . \quad (3)$$

* I am preparing for experiments to test the accuracy of this proposition.—February 18, J. P. J.

"'I have made several series of experiments, using the same conducting wire as a source of heat, a constant interval of time, and a variable current of electricity. The method adopted in these experiments was to try the effect of a wire traversed by a current of electricity—first, when it was immersed in water, and afterwards when it was immersed in another liquid. Hence I obtained two determinations of y in equation 2, one of them for water, the other for the liquid. The relation between these two quantities gave, of course, the capacity of the liquid compared with that of the water.'

"Without pretending to say that it was impossible to arrive at Joule's conclusions without the atomic theory of Dalton, we may say distinctly that it was not attained without its aid. The idea of full portions, *units of measure* in Dalton's mind, developed itself gradually into *units of force* in the mind of Joule, and it is in this form that we received it from the hand of one illustrious member still active amongst us. To say that the two are the most successful descendants of the great thinkers who have grappled with the subject of atoms for three thousand years is but to express a simple fact; and to assert that Dalton and he have made the great leading discoveries on the subject is simply to follow history. From one we learn the order in which the ultimate particles of bodies move, from the other we learn the force and relation of their movements in those great phenomena, heat, electricity, and mechanical force.

"It is of course impossible to deny great honour to many men who have laboured on heat. We have great admiration for the work of Dulong and Petit, great illustrators of atomic action. We may delight in the speculative ideas of Clausius, Helmholtz, Clerk Maxwell, and Sir William Thomson, but we must remember that these men represent another department of atomic study.

"They take the Daltonian atom as granted. They take it also as Joule, Dalton's pupil, made it—a measure of power, and they seek to go further in studying its physical properties. We have here a follower worthy of the prophet. Dalton's pupil has become the master of many learners."

A TELEGRAPHER'S PRACTICAL JOKE.*

BY WITT MASTER.

In any large office where there are so many people employed as in the main office of the Western Union Company, New York, the various cliques that are formed afford an interesting study to the close observer.

There will be one clique of perhaps twenty persons, all having a certain amount of affinity for each other, and all of whom will act and think together, somewhat unanimously, on a great many different subjects.

It is not necessary that they should be of one political or religious belief, for every phase of political and religious creed may be represented in the clique. Within this clique there may be two distinct cliques, composed of those whose tastes and inclinations run still more closely together, and again and again the circle will divide or contract until we find it composed of rings of two or three fraternal and congenial spirits, those confiding in one another their troubles and pleasures, their failures and successes in their business and domestic lives.

Of course these cliques of the first larger kind run to various hobbies; some of them will favour athletics, some politics, others music, others scientific studies and so on, and it is about as difficult to divert the attention of the athletic loving from a base-ball match to a musical festival as to induce the embryo politician to attend a scientific lecture, and *vice versa*. But when a hint is thrown out that a joke is being or is about to be perpetrated on any one in the numerous cliques, it is amusing to watch the eagerness with which every one aids and abets the prime mover in his effort to carry out the joke successfully.

One of the best and most prolonged of these happened quite recently.

It appears that one of a party of four cronies who regularly

* There is perhaps more truth in this account of a joke than would be generally supposed, and we should not wonder if St. Martin's-le-Grand could supply a number of joking experiences.—ED. *E.*

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sit at a certain table in the lunch room in the Western Union Building, and whom I shall designate as "the victim," was detained for a few minutes by the visit of a friend from the country. The victim, as he sat down, gave expression to the wish that the next time any of his friends called they would do so at a more convenient season than the lunch half-hour, and especially that they would not call when under the slightest influence of liquor, which he intimated was one of the failings of his friend. He further incautiously remarked that his friend was Thompson, from Cold Spring, N.Y., and that he Thompson, and his wife, had come down to attend a wedding in Brooklyn.

This was sufficient basis on which to build a joke, and his hearers lost little time in putting one into execution, as follows:

About half an hour after dinner the victim received a telegram, purporting to be from the Fifth Avenue Hotel, which read:—

"I am having a rollicking time. Meet me here at five o'clock. THOMPSON."

The victim was seen to stick the message hastily in his pocket, and then he wrote an answer to the effect that a previous engagement would prevent acceptance of invitation.

Half an hour later the victim was called to the ostensible hotel wire, and the operator there informed him that a man by the name of Thompson was acting very boisterously, and had already broken several windows of the hotel. The hotel operator further stated that Mr. T. was shouting that he and his friend (the victim), of the Western Union, could clean out the entire hotel. The operator concluded by asking the victim to come up at once to the hotel. "But what good can I do?" wailed the victim over the wire. "You may be able to pacify him," was the reply, to which was added, "Wait a moment; I will see you again."

After another delay the victim was recalled to the hotel wire, and was informed that they had succeeded in quieting Mr. Thompson, and that a couple of porters were now bringing him to the victim's office. This horrified the victim, who conjured up a disgraceful scene. He therefore obtained leave to go down stairs for a few minutes on the plea of sudden illness, but in reality with the hope of intercepting his boisterous friend.

After waiting half an hour and finding no sign of Mr. Thompson's arrival, he ventured to leave his post of sentry and returned to his desk, but scarcely was he seated before he was again called to the hotel wire, this time to be informed that his friend had become almost unmanageable; but as he had expressed a desire to return home at once, the porters had taken him to the Grand Central Depôt, where he had got aboard the 3:30 p.m. train for Cold Spring, N.Y.

This was a great relief to the victim, but his thoughts at once turned to his friend's wife, who was now awaiting her truant husband's company to the wedding. The victim felt it to be his duty to call and inform Mrs. Thompson of her husband's whereabouts. He therefore provided himself with a substitute, but before leaving the office he received another message from Mr. Thompson, stating that "the robbers at the hotel had stolen his hat; would not the victim call and get it, or report it to the police?"

On his way to Brooklyn, he called to see the proprietor of a cigar store, who was a mutual friend of all the parties, to whom he related the above occurences, and they both concluded that Mr. Thompson was undoubtedly crazy from drink.

The cigar dealer and the victim then decided to go together to where Mrs. T. was stopping, to break the unpleasant news to her.

They reached their destination in due time, and talked of the weather and everything but the real object of their call, both gentlemen fearing to broach the painful topic, and each hoping the other would do so first. While they were thus hesitating, a rap was heard at the door, and Mr. Thompson entered, sober and in his right mind, and expressed his surprise and pleasure at meeting the visitors.

The cigar dealer looked at the victim inquiringly for an explanation, but the latter, having at last grasped the fact that he had been somewhat imposed upon by his office mates, winked at his friend and immediately recollected an engagement they both had further down the street, and drew his friend off with him.

It is, of course, unnecessary to say that all the messages and conversations upon the wire were concocted, and carried on by the victim's friends in the office, over a dozen of whom were in the secret and were watching his every movement.—*The Operator.*

THE BRITISH ASSOCIATION MEETING AT MONTREAL.

The following is the Presidential Address by Lord Rayleigh, F.R.S., delivered at the B. A. meeting at Montreal, on Wednesday, August 27:—

It is no ordinary meeting of the British Association which I have now the honour of addressing. For more than fifty years the Association has held its autumn gathering in various towns of the United Kingdom, and within those limits there is, I suppose, no place of importance which we have not visited. And now, not satisfied with past successes, we are seeking new worlds to conquer. When it was first proposed to visit Canada, there were some who viewed the project with hesitation. For my own part I never quite understood the grounds of their apprehension. Perhaps they feared the thin edge of the wedge. When once the principle was admitted there was no knowing to what it might lead. So rapid is the development of the British Empire, that the time might come when a visit to such out-of-the-way places as London or Manchester could no longer be claimed as a right, but only asked for as a concession to the susceptibilities of the English. But seriously, whatever objections may have at first been felt were soon outweighed by the consideration of the magnificent opportunities which your hospitality affords of extending the sphere of our influence and of becoming acquainted with a part of the Queen's dominion which, associated with splendid memories of the past, is advancing daily by leaps and bounds to a position of importance such as not long ago was scarcely dreamed of. For myself, I am not a stranger to your shores. I remember well the impression made upon me, seventeen years ago, by the wild rapids of the St. Lawrence, and the gloomy grandeur of the Saguenay. If anything impressed me more, it was the kindness with which I was received by yourselves, and which I doubt not will be again extended not merely to myself, but to all the English members of the Association. I am confident that those who have made up their minds to cross the ocean will not repent their decision, and that, apart altogether from scientific interests, great advantage may be expected from this visit. We Englishmen ought to know more than we do of matters relating to the Colonies, and anything which tends to bring the various parts of the Empire into closer contact can hardly be overvalued. It is pleasant to think that this Association is the means of furthering an object which should be dear to the hearts of all of us; and I venture to say that a large proportion of the visitors to this country will be astonished by what they see, and will carry home an impression which time will not readily efface.

To be connected with this meeting is to me a great honour, but also a great responsibility. In one respect especially I feel that the Association might have done well to choose another president. My own tastes have led me to study mathematics and physics rather than geology and biology, to which naturally more attention turns in a new country, presenting as it does a fresh field for investigation. A chronicle of achievements in these departments by workers from among yourselves would have been suitable to the occasion, but could not come from me. If you would have preferred a different subject for this address, I hope, at least, that you will not hold me entirely responsible.

At annual gatherings like ours the pleasure with which friends meet friends again is sadly marred by the absence of those who can never more take their part in our proceedings. Last year my predecessor in this office had to lament the untimely loss of Spottiswoode and Henry Smith, dear friends of many of us, and prominent members of our Association. And now, again, a well-known form is missing. For many years Sir W. Siemens has been a regular attendant at our meetings, and to few indeed have they been more indebted for success. Whatever the occasion, in his presidential address of two years ago, or in communications to the physical and mechanical sections, he had always new and interesting ideas, put forward in language which a child could understand, so great a master was he of the art of lucid statement in his adopted tongue. Practice with science was his motto. Deeply engaged in industry, and conversant all his life with engineering operations, his opinion was never that of a mere theorist. On the other hand, he abhorred rule of thumb, striving always to master the scientific principles which underlie rational design and invention.

It is not necessary that I should review in detail the work of Siemens. The part which he took during recent years in the development of the dynamo machine must be known to many of you. We owe to him the practical adoption of the method, first suggested by Wheatstone, of throwing into a shunt the coils of the field-magnets, by which a greatly improved steadiness of action is obtained. The same characteristics are observable throughout—a definite object in view and a well-directed perseverance in overcoming the difficulties by which the path is usually obstructed.

These are, indeed, the conditions of successful invention. The world knows little of such things, and regards the new machine or the new method as the immediate outcome of a happy idea. Probably, if the truth were known, we should see that, in nine cases out of ten, success depends as much upon good judgment and perseverance as upon fertility

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of imagination. The labours of our great inventors are not unappreciated, but I doubt whether we adequately realise the enormous obligations under which we lie. It is no exaggeration to say that the life of such a man as Siemens is spent in the public service, the advantages which he reaps for himself being as nothing in comparison with those which he confers upon the community at large.

As an example of this it will be sufficient to mention one of the most valuable achievements of his active life—his introduction, in conjunction with his brother, of the Regenerative Gas Furnace, by which an immense economy of fuel (estimated at millions of tons annually) has been effected in the manufacture of steel and glass. The nature of this economy is easily explained. Whatever may be the work to be done by the burning of fuel, a certain *temperature* is necessary. For example, no amount of heat in the form of boiling water, would be of any avail for the fusion of steel. When the products of combustion are cooled down to the point in question, the heat which they still contain is useless as regards the purpose in view. The importance of this consideration depends entirely upon the working temperature. If the object be the evaporation of water or the warming of a house, almost all the heat may be extracted from the fuel without special arrangements. But it is otherwise when the temperature required is not much below that of combustion itself, for then the escaping gases carry away with them the larger part of the whole heat developed. It was to meet this difficulty that the regenerative furnace was devised. The products of combustion, before dismissal into the chimney, are caused to pass through piles of loosely stacked fire-brick, to which they give up their heat. After a time the fire-brick, upon which the gases first impinge, becomes nearly as hot as the furnace itself. By suitable valves the burnt gases are then diverted through another stack of brickwork, which they heat up in like manner, while the heat stored up in the first stack is utilised to warm the unburnt gas and air on their way to the furnace. In this way almost all the heat developed at a high temperature during the combustion is made available for the work in hand.

As it is now several years since your presidential chair has been occupied by a professed physicist, it may naturally be expected that I should attempt some record of recent progress in that branch of science, if indeed such a term be applicable. For it is one of the difficulties of the task that subjects as distinct as Mechanics, Electricity, Heat, Optics, and Acoustics, to say nothing of Astronomy and Meteorology, are included under Physics. Any one of these may well occupy the life-long attention of a man of science, and to be thoroughly conversant with all of them is more than can be expected of any one individual, and is probably incompatible with the devotion of much time and energy to the actual advancement of knowledge. Not that I would complain of the association sanctioned by common parlance. A sound knowledge of at least the principles of general physics is necessary to the cultivation of any department. The predominance of the sense of sight as the medium of communication with the outer world brings with it dependence upon the science of optics; and there is hardly a branch of science in which the effects of *temperature* have not (often without much success) to be reckoned with. Besides, the neglected borderland between two branches of knowledge is often that which best repays cultivation, or, to use a metaphor of Maxwell's, the greatest benefits may be derived from a cross fertilisation of the sciences. The wealth of material is an evil only from the point of view of one of whom too much may be expected. Another difficulty incident to the task, which must be faced but cannot be overcome, is that of estimating rightly the value, and even the correctness, of recent work. It is not always that which seems at first the most important that proves in the end to be so. The history of science teems with examples of discoveries which attracted little notice at the time, but afterwards have taken root downwards and borne much fruit upwards.

One of the most striking advances of recent years is in the production and application of electricity upon a large scale—a subject to which I have already had occasion to allude in connection with the work of Sir W. Siemens. The dynamo machine is, indeed, founded upon discoveries of Faraday now more than half a century old; but it has required the protracted labours of many inventors to bring it to its present high degree of efficiency. Looking back at the matter, it seems strange that progress should have been so slow. I do not refer to details of design, the elaboration of which must always, I suppose, require the experience of actual work to indicate what parts are structurally weaker than they should be, or are exposed to undue wear and tear. But with regard to the main features of the problem, it would almost seem as if the difficulty lay in want of faith. Long ago it was recognised that electricity derived from chemical action is, on a large scale, too expensive a source of mechanical power, notwithstanding the fact that, as proved by Joule in 1846, the conversion of electrical into mechanical work can be effected with great economy. From this it is an evident consequence that electricity may advantageously be obtained from mechanical power; and one cannot help thinking that if the fact had been borne steadily in mind the development of the dynamo might have been much more rapid. But discoveries and inventions are apt to appear obvious when regarded from the standpoint of accomplished fact; and I draw attention to the matter only to point the moral that we do well to push the attack persistently when we can be sure beforehand that the obstacles to be overcome are only difficulties of contrivance, and that we are not vainly fighting unawares against a law of Nature.

The present development of electricity on a large scale depends, however, almost as much upon the incandescent lamp as upon the dynamo. The success of these lamps demands a very perfect vacuum—not more than about one-millionth of the normal quantity of air should remain—and it is interesting to recall that, twenty years ago, such vacua were rare even in the laboratory of the physicist. It is pretty safe to say that these wonderful results would never have been accomplished had practical applications alone been in view. The way was prepared by an army of scientific men whose main object was the advancement of knowledge, and who could scarcely have imagined that the processes which they elaborated would soon be in use on a commercial scale and entrusted to the hands of ordinary workmen.

When I speak in hopeful language of practical electricity, I do not forget the disappointment within the last year or two of many oversanguine expectations. The enthusiasm of the inventor and promoter are necessary to progress, and it seems to be almost a law of nature that it should overpass the bounds marked out by reason and experience. What is most to be regretted is the advantage taken by speculators of the often uninstructed interest felt by the public in novel schemes by which its imagination is fired. But looking forward to the future of electric lighting, we have good ground for encouragement. Already the lighting of large passsenger ships is an assured success, and one which will be highly appreciated by those travellers who have experienced the tedium of long winter evenings unrelieved by adequate illumination. Here, no doubt, the conditions are in many respects especially favourable. As regards space, life on board ship is highly concentrated; while unity of management and the presence on the spot of skilled engineers obviate some of the difficulties that are met with under other circumstances. At present we have no experience of a house-to-house system of illumination on a great scale and in competition with cheap gas; but preparations are already far advanced for trial on an adequate scale in London. In large institutions, such as theatres and factories, we all know that electricity is in successful and daily extending operation.

When the necessary power can be obtained from the fall of water, instead of from the combustion of coal, the conditions of the problem are far more favourable. Possibly the severity of your winters may prove an obstacle, but it is impossible to regard your splendid river without the thought arising that the day may come when the vast powers now running to waste shall be bent into your service. Such a project demands of course the most careful consideration, but it is one worthy of an intelligent and enterprising community.

The requirements of practice react in the most healthy manner upon scientific electricity. Just as in former days the science received a stimulus from the application to telegraphy, under which everything relating to measurement on a small scale acquired an importance and development for which we might otherwise have had long to wait, so now the requirements of electric lighting are giving rise to a new development of the art of measurement upon a large scale, which cannot fail to prove of scientific as well as practical importance. Mere change of scale may not at first appear a very important matter, but it is surprising how much modification it entails in the instruments, and in the processes of measurement. For instance, the resistance coils on which the electrician relies in dealing with currents whose maximum is a fraction of an ampere, fail altogether when it becomes a question of hundreds, not to say thousands, of amperes.

The powerful currents which are now at command constitute almost a new weapon in the hands of the physicist. Effects which in old days were rare and difficult of observation may now be produced at will on the most conspicuous scale. Consider for a moment Faraday's great discovery of the "Magnetisation of Light," which Tyndall likens to the Weisshorn among mountains, as high, beautiful and alone. This judgment (in which I fully concur) relates to the scientific aspect of the discovery, for to the eye of sense nothing could have been more insignificant. It is even possible that it might have eluded altogether the penetration of Faraday, had he not been provided with a special quality of very heavy glass. At the present day these effects may be produced upon a scale that would have delighted their discoverer, a rotation of the plane of polarisation through 180° being perfectly feasible. With the aid of modern appliances, Kundt and Röntgen in Germany, and H. Becquerel in France, have detected the rotation in gases and vapours, where, on account of its extreme smallness, it had previously escaped notice.

Again, the question of the magnetic saturation of iron has now an importance entirely beyond what it possessed at the time of Joule's early observations. Then it required special arrangements purposely contrived to bring it into prominence. Now in every dynamo machine the iron of the field magnets approaches a state of saturation, and the very elements of an explanation of the action require us to take the fact into account. It is indeed probable that a better knowledge of this subject might lead to improvements in the design of these machines.

Notwithstanding the important work of Rowland and Stowletow, the whole theory of the behaviour of soft iron under varying magnetic conditions is still somewhat obscure. Much may be hoped from the induction balance of Hughes, by which the marvellous powers of the telephone are applied to the discrimination of the properties of metals, as regards magnetism and electric conductivity.

The introduction of powerful alternate currents in machines by Siemens, Gordon, Ferranti, and others, is likely also to have a salutary effect in educating those so-called practical electricians whose ideas do not easily rise above ohms and volts. It has long been known that when the changes are sufficiently rapid, the phenomena are governed much more by induction, or electric inertia, than by mere resistance. On this principle much may be explained that would otherwise seem paradoxical. To take a comparatively simple case, conceive an electro-magnet wound with two contiguous wires, upon which acts a given rapidly periodic electromotive force. If one wire only be used, a certain amount of heat is developed in the circuit. Suppose now that the second wire is brought into operation in parallel—a proceeding equivalent to doubling the section of the original wire. An electrician accustomed only to constant currents would be sure to think that the heating effect would be doubled by the change, as much heat being developed in each wire separately as was at first in the single wire. But such a conclusion would be entirely erroneous. The total current, being governed practically by the self-induction of the circuit, would not be augmented by the accession of the second wire, and

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the total heating effect, so far from being doubled, would, in virtue of the superior conductivity, be halved.

During the last few years much interest has been felt in the reduction to an absolute standard of measurements of electromotive force, current, resistance, &c., and to this end many laborious investigations have been undertaken. The subject is one that has engaged a good deal of my own attention, and I should naturally have felt inclined to dilate upon it, but that I feel it to be too abstruse and special to be dealt with in detail upon an occasion like the present. As regards resistance, I will merely remind you that the recent determinations have shown a so greatly improved agreement, that the Conference of Electricians assembled at Paris, in May, have felt themselves justified in defining the ohm for practical use as the resistance of a column of mercury of 0deg. C., 1 square millimetre in section, and 106 centimetres in length—a definition differing by a little more than 1 per cent. from that arrived at 20 years ago by a committee of this Association.

A standard of resistance once determined upon can be embodied in a "resistance coil," and copied without much trouble, and with great accuracy. But, in order to complete the electrical system, a second standard of some kind is necessary, and this is not so easily embodied in a permanent form. It might conveniently consist of a standard galvanic cell, capable of being prepared in a definite manner, whose electromotive force is once for all determined. Unfortunately, most of the batteries in ordinary use are for one reason or another unsuitable for this purpose, but the cell introduced by Mr. Latimer Clark, in which the metals are zinc in contact with saturated zinc sulphate and pure mercury in contact with mercurous sulphate, appears to give satisfactory results. According to my measurements, the electromotive force of this cell is 1·435 theoretical volts.

We may also conveniently express the second absolute electrical measurement necessary to the completion of the system by taking advantage of Faraday's law, that the quantity of metal decomposed in an electrolytic cell is proportional to the whole quantity of electricity that passes. The best metal for the purpose is silver, deposited from a solution of the nitrate or of the chlorate. The results recently obtained by Professor Kohlrausch and by myself are in very good agreement, and the conclusion that one ampere flowing for one hour decomposes 4·025 grains of silver can hardly be in error by more than a thousandth part. This number being known, the silver voltameter gives a ready and very accurate method of measuring currents of intensity, varying from 1-10 ampere to four or five amperes.

The beautiful and mysterious phenomena attending the discharge of electricity in nearly vacuous spaces have been investigated and in some degree explained by De la Rue, Crookes, Schuster, Moulton, and the lamented Spottiswoode, as well as by various able foreign experimenters. In a recent research Crookes has sought the origin of a bright citron-coloured band in the phosphorescent spectrum of certain earths, and after encountering difficulties and anomalies of a most bewildering kind, has succeeded in proving that it is due to yttrium, an element much more widely distributed than had been supposed. A conclusion like this is stated in a few words, but those only who have undergone similar experience are likely to appreciate the skill and perseverance of which it is the final reward.

A remarkable observation by Hall, of Baltimore, from which it appeared that the flow of electricity in a conducting sheet was disturbed by magnetic force, has been the subject of much discussion. Mr. Shelford Bidwell has brought forward experiments tending to prove that the effect is of a secondary character, due in the first instance to the mechanical force operating upon the conductor of an electric current when situated in a powerful magnetic field. Mr. Bidwell's view agrees in the main with Mr. Hall's division of the metals into two groups according to the direction of the effect.

Without doubt the most important achievement of the older generation of scientific men has been the establishment and application of the great laws of thermo-dynamics, or, as it is often called, the mechanical theory of heat. The first law, which asserts that heat and mechanical work can be transformed one into the other at a certain fixed rate, is now well understood by every student of physics, and the number expressing the mechanical equivalent of heat resulting from the experiments of Joule, has been confirmed by the researches of others, and especially of Rowland. But the second law, which practically is even more important than the first, is only now beginning to receive the full appreciation due to it. One reason of this may be found in a not unnatural confusion of ideas. Words do not always lend themselves readily to the demands that are made upon them by a growing science, and I think that the almost unavoidable use of the word equivalent in the statement of the first law is partly responsible for the little attention that is given to the second. For the second law so far contradicts the usual statement of the first, as to assert that equivalents of heat and work are not of equal value. While work can always be converted into heat, heat can only be converted into work under certain limitations. For every practical purpose the work is worth the most, and when we speak of equivalents, we use the word in the same sort of special sense as that in which chemists speak of equivalents of gold and iron. The second law teaches us that the real value of heat, as a source of mechanical power, depends upon the temperature of the body in which it resides; the hotter the body in relation to its surroundings, the more available the heat.

In order to see the relations which obtain between the first and the second law of thermo-dynamics, it is only necessary for us to glance at the theory of the steam engine. Not many years ago calculations were plentiful, demonstrating the inefficiency of the steam engine on the basis of a comparison of the work actually got out of the engine with the mechanical equivalent of the heat supplied to the boiler. Such calculations took into account only the first law of thermo-dynamics, which deals with the equivalents of heat and work, and have very little bearing upon the practical question of efficiency, which requires us to have regard also to the second law. According to that law the fraction of the total energy which can be converted into work depends upon the relative temperatures of the boiler and condenser; and it is therefore manifest that, as the temperature of the boiler cannot be raised indefinitely, it is impossible to utilise all the energy which, according to the first law of thermo-dynamics, is resident in the coal.

On a sounder view of the matter, the efficiency of the steam engine is found to be so high that there is no great margin remaining for improvement. The higher initial temperature possible in the gas engine opens out much wider possibilities, and many good judges look forward to a time when the steam engine will have to give way to its younger rival.

To return to the theoretical question, we may say with Sir W. Thomson, that though energy cannot be destroyed, it ever tends to be dissipated, or to pass from more available to less available forms. No one who has grasped this principle can fail to recognise its immense importance in the system of the Universe. Every change—chemical, thermal, or mechanical—which takes place, or can take place, in Nature does so at the cost of a certain amount of available energy. If, therefore, we wish to inquire whether or not a proposed transformation can take place, the question to be considered is whether its occurrence would involve dissipation of energy. If not, the transformation is (under the circumstances of the case) absolutely excluded. Some years ago, in a lecture at the Royal Institution, I endeavoured to draw the attention of chemists to the importance of the principle of dissipation in relation to their science, pointing out the error of the usual assumption that a general criterion is to be found in respect to the development of heat. For example, the solution of a salt in water is, if I may be allowed the phrase, a downhill transformation. It involves dissipation of energy, and can therefore go forward; but in many cases it is associated with the absorption rather than with the development of heat. I am glad to take advantage of the present opportunity in order to repeat my recommendation, with an emphasis justified by actual achievement. The foundations laid by Thomson now bear an edifice of no mean proportions, thanks to the labours of several physicists, among whom must be especially mentioned, Willard Gibbs and Helmholtz. The former has elaborated a theory of the equilibrium of heterogeneous substances, wide in its principles, and we cannot doubt far-reaching in its consequences. In a series of masterly papers Helmholtz has developed the conception of *free energy* with very important applications to the theory of the galvanic cell. He points out that the mere tendency to solution bears in some cases no small proportion to the affinities more usually reckoned chemical, and contributes largely to the total electromotive force. Also in our own country Dr. Alder Wright has published some valuable experiments relating to the subject.

From the further study of electrolysis we may expect to gain improved views as to the nature of the chemical reactions, and of the forces concerned in bringing them about. I am not qualified—I wish I were—to speak to you on recent progress in general chemistry. Perhaps my feelings towards a first love may blind me, but I cannot help thinking that the next great advance, of which we have already some foreshadowing, will come on this side. And if I might without presumption venture a word of recommendation, it would be in favour of a more minute study of the simpler chemical phenomena.

Under the head of scientific mechanics it is principally in relation to fluid motion that advances may be looked for. In speaking upon this subject I must limit myself almost entirely to experimental work. Theoretical hydro-dynamics, however important and interesting to the mathematician, are eminently unsuited to oral exposition. All I can do to attenuate an injustice to which theorists are pretty well accustomed is to refer you to the admirable reports of Mr. Hicks, published under the auspices of this association.

The important and highly practical work of the late Mr. Froude in relation to the propulsion of ships is doubtless known to most of you. Recognising the fallacy of views then widely held as to the nature of the resistance to be overcome, he showed to demonstration that, in the case of fair-shaped bodies, we have to deal almost entirely with resistance dependent upon skin friction, and at high speeds upon the generation of surface waves by which energy is carried off. At speeds which are moderate in relation to the size of the ship, the resistance is practically dependent upon skin friction only. Although Professor Stokes and other mathematicians had previously published calculations pointing to the same conclusion, there can be no doubt that the view generally entertained was very different. At the first meeting of the Association which I ever attended, as an intelligent listener, at Bath in 1864, I well remember the surprise which greeted a statement by Rankine that he regarded skin friction as the only legitimate resistance to the progress of a well designed ship. Mr. Froude's experiments have set the question at rest in a manner satisfactory to those who had little confidence in theoretical prevision.

In speaking of an explanation as satisfactory in which skin friction is accepted as the cause of resistance, I must guard myself against being supposed to mean that the nature of skin friction is itself well understood. Although its magnitude varies with the smoothness of the surface, we have no reason to think that it would disappear at any degree of smoothness consistent with an ultimate molecular structure. That it is connected with fluid viscosity is evident enough, but the *modus operandi* is still obscure.

Some important work bearing upon the subject has recently been published by Professor O. Reynolds, who has investigated the flow of water in tubes as dependent upon the velocity of motion and upon the size of the bore. The laws of motion in capillary tubes, discovered experimentally by Poiseuille, are in complete harmony with theory. The resistance varies as the velocity, and depends in a direct manner upon the constant of viscosity. But when we come to the larger pipes and higher velocities with which engineers usually have to deal, the theory which presupposes

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a regularly stratified motion evidently ceases to be applicable, and the problem becomes essentially identical with that of skin friction in relation to ship propulsion. Professor Reynolds has traced with much success the passage from the one state of things to the other, and has proved the applicability under these complicated conditions of the general laws of dynamical similarity as adapted to viscous fluids by Professor Stokes. In spite of the difficulties which beset both the theoretical and experimental treatment, we may hope to attain before long to a better understanding of a subject which is certainly second to none in scientific as well as practical interest.

As also closely connected with the mechanics of viscous fluids, I must not forget to mention an important series of experiments upon the friction of oiled surfaces, recently executed by Mr. Tower for the Institution of Mechanical Engineers. The results go far towards upsetting some ideas hitherto widely admitted. When the lubrication is adequate, the friction is found to be nearly independent of the load, and much smaller than is usually supposed, giving a coefficient as low as $\frac{1}{1000}$. When the layer of oil is well formed, the pressure between the solid surfaces is really borne by the fluid, and the work lost is spent in shearing, that is, in causing one stratum of the oil to glide over another.

In order to maintain its position, the fluid must possess a certain degree of viscosity proportionate to the pressure; and even when this condition is satisfied, it would appear to be necessary that the layer should be thicker on the ingoing than on the outgoing side. We may, I believe, expect from Professor Stokes a further elucidation of the processes involved. In the meantime, it is obvious that the results already obtained are of the utmost value, and fully justify the action of the Institution in devoting a part of its resources to experimental work. We may hope, indeed, that the example thus wisely set may be followed by other public bodies associated with various departments of industry.

I can do little more than refer to the interesting observations of Professor Darwin, Mr. Hunt, and M. Forel on Ripplemark. The processes concerned would seem to be of a rather intricate character, and largely dependent upon fluid viscosity. It may be noted, indeed, that most of the still obscure phenomena of hydro-dynamics require for their elucidation a better comprehension of the laws of viscous motion. The subject is one which offers peculiar difficulties. In some problems in which I have lately been interested, a circulating motion presents itself of the kind which the mathematician excludes from the first when he is treating of fluids destitute altogether of viscosity. The intensity of this motion proves, however, to be independent of the coefficient of viscosity, so that it cannot be correctly dismissed from consideration as a consequence of a supposition that the viscosity is infinitely small. The apparent breach of continuity can be explained, but it shows how much care is needful in dealing with the subject, and how easy it is to fall into error.

The nature of gaseous viscosity, as due to the diffusion of momentum, has been made clear by the theoretical and experimental researches of Maxwell. A flat disc moving in its own plane between two parallel solid surfaces is impeded by the necessity of shearing the intervening layers of gas, and the magnitude of the hindrance is proportional to the velocity of the motion and to the viscosity of the gas, so that under similar circumstances this effect may be taken as a measure, or rather definition, of the viscosity. From the dynamical theory of gases, to the development of which he contributed so much, Maxwell drew the startling conclusion that the viscosity of a gas should be independent of its density—that within wide limits the resistance to the moving disc should be scarcely diminished by pumping out the gas, so as to form a partial vacuum. Experiment fully confirmed this theoretical anticipation, —one of the most remarkable to be found in the whole history of science, and proved that the swinging disc was retarded by the gas, as much when the barometer stood at half an inch as when it stood at thirty inches. It was obvious, of course, that the law must have a limit, that at a certain point of exhaustion the gas must begin to lose its power; and I remember discussing with Maxwell, soon after the publication of his experiments, the whereabouts of the point at which the gas would cease to produce its ordinary effect. His apparatus, however, was quite unsuited for high degrees of exhaustion, and the failure of the law was first observed by Kundt and Warburg, as pressures below 1 mm. of mercury. Subsequently the matter has been thoroughly examined by Crookes, who extended his observations to the highest degrees of exhaustion as measured by M'Leod's gauge. Perhaps the most remarkable results relate to hydrogen. From the atmospheric pressure of 760 mm. down to about ½ mm. of mercury the viscosity is sensibly constant. From this point to the highest vacua, in which less than one-millionth of the original gas remains, the coefficient of viscosity drops down gradually to a small fraction of its original value. In these vacua Mr. Crookes regards the gas as having assumed a different ultra-gaseous condition; but we must remember that the phenomena have relation to the other circumstances of the case, especially the dimensions of the vessel, as well as to the condition of the gas.

Such an achievement as the prediction of Maxwell's law of viscosity has, of course, drawn increased attention to the dynamical theory of gases. The success which has attended the theory in the hands of Clausius, Maxwell, Boltzmann and other mathematicians, not only in relation to viscosity, but over a large part of the entire field of our knowledge of gases, proves that some of its fundamental postulates are in harmony with the reality of Nature. At the same time, it presents serious difficulties; and we cannot but feel that while the electrical and optical properties of gases remain out of relation to the theory no final judgment is possible. The growth of experimental knowledge may be trusted to clear up many doubtful points, and a younger generation of theorists will bring to bear improved mathematical weapons. In the meantime we may fairly congratulate ourselves on the possession of a guide which has already conducted us to a position which could hardly otherwise have been attained.

In Optics attention has naturally centred upon the spectrum. The mystery attaching to the invisible rays lying beyond the red has been fathomed to an extent that, a few years ago, would have seemed almost impossible. By the use of special photographic methods Abney has mapped out the peculiarities of this region with such success that our knowledge of it begins to be comparable with that of the parts visible to the eye. Equally important work has been done by Langley, using a refined invention of his own based upon the principle of Siemens's pyrometer. This instrument measures the actual energy of the radiation, and thus expresses the effects of various parts of the spectrum upon a common scale, independent of the properties of the eye and of sensitive photographic preparations. Interesting results have also been obtained by Becquerel, whose method is founded upon a curious action of the ultra-red rays in enfeebling the light emitted by phosphorescent substances. One of the most startling of Langley's conclusions relates to the influence of the atmosphere in modifying the quality of solar light. By the comparison of observations made through varying thicknesses of air, he shows that the atmospheric absorption tells most upon the light of high refrangibility; so that to an eye situated outside the atmosphere, the sun would present a decidedly bluish tint. It would be interesting to compare the experimental numbers with the law of scattering of light by small particles given some years ago as the result of theory. The demonstration by Langley of the inadequacy of Cauchy's law of dispersion to represent the relation between refrangibility and wave-length in the lower part of the spectrum must have an important bearing upon optical theory.

The investigation of the relation of the visible and ultra-violet spectrum to various forms of matter has occupied the attention of a host of able workers, among whom none have been more successful than my colleagues at Cambridge, Professors Liveing and Dewar. The subject is too large both for the occasion and for the individual, and I must pass it by. But, as more closely related to optics proper, I cannot resist recalling to your notice a beautiful application of the idea of Doppler to the discrimination of the origin of certain lines observed in the solar spectrum. If a vibrating body have a general motion of approach or recession, the waves emitted from it reach the observer with a frequency which in the first case exceeds, and in the second case falls short of, the real frequency of the vibrations themselves. The consequence is that, if a glowing gas be in motion in the line of sight, the spectral lines are thereby displaced from the position that they would occupy were the gas at rest—a principle which, in the hands of Huggins and others, has led to a determination of the motion of certain fixed stars relatively to the solar system. But the sun is itself in rotation, and thus the position of a solar spectral line is slightly different according as the light comes from the advancing or from the retreating limb. This displacement was, I believe, first observed by Thollon; but what I now desire to draw attention to is the application of it by Cornu to determine whether a line is of solar or atmospheric origin. For this purpose a small image of the sun is thrown upon the slit of the spectroscope, and caused to vibrate two or three times a second, in such a manner that the light entering the instrument comes alternately from the advancing and retreating limbs. Under these circumstances a line due to absorption within the sun appears to tremble, as the result of slight alternately opposite displacements. But if the seat of the absorption be in the atmosphere, it is a matter of indifference from what part of the sun the light originally proceeds, and the line maintains its position in spite of the oscillation of the image upon the slit of the spectroscope. In this way Cornu was able to make a discrimination which can only otherwise be effected by a difficult comparison of appearances under various solar altitudes.

The instrumental weapon of investigation, the spectroscope itself, has made important advances. On the theoretical side we have for our guidance the law that the optical power in gratings is proportional to the total number of lines accurately ruled, without regard to the degree of closeness, and in prisms that it is proportional to the thickness of glass traversed. The magnificent gratings of Rowland are a new power in the hands of the spectroscopist, and as triumphs of mechanical art seem to be little short of perfection. In our own report for 1882, Mr. Mallock has described a machine, constructed by him, for ruling large diffraction gratings, similar in some respects to that of Rowland.

The great optical constant, the velocity of light, has been the subject of three distinct investigations by Cornu, Michelson, and Forbes. As may be supposed, the matter is of no ordinary difficulty, and it is therefore not surprising that the agreement should be less decided than could be wished. From their observations, which were made by a modification of Fizeau's method of the toothed wheel, Young and Forbes drew the conclusion that the velocity of light *in vacuo* varies from colour to colour to such an extent that the velocity of blue light is nearly two per cent. greater than that of red light. Such a variation is quite opposed to existing theoretical notions, and could only be accepted on the strongest evidence. Mr. Michelson, whose method (that of Foucault) is well suited to bring into prominence a variation of velocity with wave length, informs me that he has recently repeated his experiments with special reference to the point in question, and has arrived at the conclusion that no variation exists comparable with that asserted by Young and Forbes. The actual velocity differs little from that found from his first series of experiments, and may be taken to be 299,800 kilometres per second.

It is remarkable how many of the playthings of our childhood give rise to questions of the deepest scientific interest. The top is, or may be understood, but a complete comprehension of the kite and of the soap bubble would carry us far beyond our present stage of knowledge. In spite of the admirable investigations of Plateau, it still remains a mystery why soapy water stands almost alone among fluids a material for bubbles. The beautiful development of colour was long ago ascribed to the interference of light, called into play by the gradual thinning of the film. In accordance with this view the tint is determined solely by the thickness

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of the film and the refractive index of the fluid. Some of the phenomena are, however, so curious as to have led excellent observers like Brewster to reject the theory of thin plates, and to assume the secretion of various kinds of colouring matter. If the rim of a wine glass be dipped in soapy water, and then held in a vertical position, horizontal bands soon begin to show at the top of the film, and extend themselves gradually downwards. According to Brewster these bands are not formed by the "subsidence and gradual thinning of the film," because they maintain their horizontal position when the glass is turned round its axis. The experiment is both easy and interesting; but the conclusion drawn from it cannot be accepted. The fact is that the various parts of the film cannot quickly alter their thickness, and hence when the glass is rotated they re-arrange themselves in order of superficial density, the thinner parts floating up over, or through, the thicker parts. Only thus can the tendency be satisfied for the centre of gravity to assume the lowest possible position.

When the thickness of a film falls below a small fraction of the length of a wave of light, the colour disappears, and is replaced by an intense blackness. Professors Reinold and Rücker have recently made the remarkable observation that the whole of the black region, soon after its formation, is of uniform thickness, the passage from the black to the coloured portions being exceedingly abrupt. By two independent methods they have determined the thickness of the black film to lie between seven and fourteen millionths of a millimetre; so that the thinnest films correspond to about one-seventieth of a wave-length of light. The importance of these results in regard to molecular theory is too obvious to be insisted upon.

The beautiful inventions of the telephone and the phonograph, although in the main dependent upon principles long since established, have imparted a new interest to the study of Acoustics. The former, apart from its uses in every day life, has become in the hands of its inventor, Graham Bell, and of Hughes, an instrument of first-class scientific importance. The theory of its action is still in some respects obscure, as is shown by the comparative failure of the many attempts to improve it. In connection with some explanations that have been offered, we do well to remember that molecular changes in solid masses are inaudible in themselves, and can only be manifested to our ears by the generation of a to and fro motion of the external surface extending over a sensible area. If the surface of a solid remains undisturbed, our ears can tell us nothing of what goes on in the interior.

In theoretical acoustics progress has been steadily maintained, and many phenomena which were obscure twenty or thirty years ago have since received adequate explanation. If some important practical questions remain unsolved, one reason is that they have not yet been definitely stated. Almost everything in connection with the ordinary use of our senses presents peculiar difficulties to scientific investigation. Some kinds of information with regard to their surroundings are of such paramount importance to successive generations of living beings, that they have learned to interpret indications which, from a physical point of view, are of the slenderest character. Every day we are in the habit of recognising, without much difficulty, the quarter from which a sound proceeds, but by what steps we attain that end has not yet been satisfactorily explained. It has been proved that when proper precautions are taken we are unable to distinguish whether a pure tone (as from a vibrating tuning fork held over a suitable resonator) comes to us from in front or from behind. This is what might have been expected from an *a priori* point of view; but what would not have been expected is that with almost any other sort of sound, from a clap of the hands to the clearest vowel sound, the discrimination is not only possible but easy and instinctive. In these cases it does not appear how the possession of two ears helps us, though there is some evidence that it does; and even when sounds come to us from the right or left, the explanation of the ready discrimination which is then possible with pure tones is not so easy as might at first appear. We should be inclined to think that the sound was heard much more loudly with the ear that is turned towards than with the ear that is turned from it, and that in this way the direction was recognised. But, if we try the experiment, we find that, at any rate with notes near the middle of the musical scale, the difference of loudness is by no means so very great. The wave-lengths of such notes are long enough in relation to the dimensions of the head to forbid the formation of anything like a sound shadow in which the averted ear might be sheltered.

In concluding this imperfect survey of recent progress in physics, I must warn you emphatically that much of great importance has been passed over altogether. I should have liked to speak to you of those far reaching speculations, especially associated with the name of Maxwell, in which light is regarded as a disturbance in an electro-magnetic medium. Indeed, at one time, I had thought of taking the scientific work of Maxwell as the principal theme of this address. But, like most men of genius, Maxwell delighted in questions too obscure and difficult for hasty treatment, and thus much of his work could hardly be considered upon such an occasion as the present. His biography has recently been published, and should be read by all who are interested in science and in scientific men. His many-sided character, the quaintness of his humour, the penetration of his intellect, his simple but deep religious feeling, the affection between son and father, the devotion of husband to wife, all combine to form a rare and fascinating picture. To estimate rightly his influence upon the present state of science, we must regard not only the work that he executed himself, important as that was, but also the ideas and the spirit which he communicated to others. Speaking for myself as one who in a special sense entered into his labours, I should find it difficult to express adequately my feeling of obligation. The impress of his thoughts may be recognised in much of the best work of the present time. As a teacher and examiner he was well acquainted with the almost universal tendency of uninstructed minds to elevate phrases above things; to refer, for example, to the principle of the conservation of energy for an explanation of the persistent rotation of a fly-wheel, almost in the style of the doctor in "Le Malade Imaginaire," who explains the fact that opium sends you to sleep by its soporific virtue. Maxwell's endeavour was always to keep the facts in the foreground, and to his influence, in conjunction with that of Thomson and Helmholtz, is largely due that elimination of unnecessary hypothesis which is one of the distinguishing characteristics of the science of the present day.

In speaking unfavourably of superfluous hypothesis, let me not be misunderstood. Science is nothing without generalisations. Detached and ill-assorted facts are only raw material, and in the absence of a theoretical solvent have but little nutritive value. At the present time and in some departments, the accumulation of material is so rapid that there is danger of indigestion. By a fiction as remarkable as any to be found in law, what has once been published, even though it be in the Russian language, is usually spoken of as "known," and it is often forgotten that the rediscovery in the library may be a more difficult and uncertain process than the first discovery in the laboratory. In this matter we are greatly dependent upon annual reports and abstracts, issued principally in Germany, without which the search for the discoveries of a little-known author would be well-nigh hopeless. Much useful work has been done in this direction in connection with our Association. Such critical reports as those upon hydro-dynamics, upon tides, and upon spectroscopy, guide the investigator to the points most requiring attention, and in discussing past achievements contribute in no small degree to future progress. But though good work has been done, much yet remains to do.

If, as is sometimes supposed, science consisted in nothing but the laborious accumulation of facts, it would soon come to a standstill, crushed, as it were, under its own weight. The suggestion of a new idea, or the detection of a law, supersedes much that had previously been a burden upon the memory, and by introducing order and coherence facilitates the retention of the remainder in an available form. Those who are acquainted with the writings of the older electricians will understand my meaning when I instance the discovery of Ohm's law as a step by which the science was rendered easier to understand and to remember. Two processes are thus at work side by side, the reception of new material and the digestion and assimilation of the old; and as both are essential, we may spare ourselves the discussion of their relative importance. One remark, however, should be made. The work which deserves, but I am afraid does not always receive, the most credit is that in which discovery and explanation go hand in hand, in which not only are new facts presented, but their relation to old ones is pointed out.

In making oneself acquainted with what has been done in any subject it is good policy to consult first the writers of highest general reputation. Although in scientific matters we should aim at independent judgment, and not rely too much upon authority, it remains true that a good deal must often be taken upon trust. Occasionally an observation is so simple and easily repeated that it scarcely matters from whom it proceeds; but as a rule it can hardly carry full weight when put forward by a novice, whose care and judgment there has been no opportunity of testing, and whose irresponsibility may tempt him to "take shots," as it is called. Those who have had experience in accurate work know how easy it would be to save time and trouble by omitting precautions and passing over discrepancies, and yet, even without dishonest intention, to convey the impression of conscientious attention to details. Although the most careful and experienced cannot hope to escape occasional mistakes, the effective value of this kind of work depends much upon the reputation of the individual responsible for it.

In estimating the present position and prospects of experimental science there is good ground for encouragement. The multiplication of laboratories gives to the younger generation opportunities such as have never existed before, and which excite the envy of those who have had to learn in middle life much that now forms part of an undergraduate course. As to the management of such institutions there is room for a healthy difference of opinion. For many kinds of original work, especially in connection with accurate measurement, there is need of expensive apparatus; and it is often difficult to persuade a student to do his best with imperfect appliances when he knows that by other means a better result could be attained with greater facility. Nevertheless it seems to me important to discourage too great reliance upon the instrument maker. Much of the best original work has been done with the homeliest appliances; and the endeavour to turn to the best account the means that may be at hand develops ingenuity and resource more than the most elaborate determinations with ready-made instruments. There is danger otherwise that the experimental education of a plodding student should be too mechanical and artificial, so that he is puzzled by small changes of apparatus much as many school boys are puzzled by a transposition of the letters in a diagram of Euclid.

From the general spread of a more scientific education we are warranted in expecting important results. Just as there are some brilliant literary men with an inability, or at least a distaste practically amounting to inability, for scientific ideas, so there are a few with scientific tastes whose imaginations are never touched by merely literary studies. To save these from intellectual stagnation during several important years of their lives is something gained; but the thorough-going advocates of scientific education aim at much more. To them it appears strange, and almost monstrous, that the dead languages should hold the place they do in general education; and it can hardly be denied that their supremacy is the result of routine rather than of argument. I do not myself take up the extreme position. I doubt whether an exclusively scientific training would be satisfactory; and where there is plenty of time and a literary aptitude I can believe that Latin and Greek may make a good foundation. But it is useless to discuss the question upon the supposition that the majority of boys attain either to a knowledge of the languages or to an appreciation of the writings of the ancient authors. The contrary is notoriously the truth, and the defenders of the existing system usually

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take their stand upon the excellence of its discipline. From this point of view there is something to be said. The laziest boy must exert himself a little in puzzling out a sentence with grammar and dictionary, while instruction and supervision are easy to organise and not too costly. But when the case is stated plainly few will agree that we can afford so entirely to disregard results. In after life the intellectual energies are usually engrossed with business, and no further opportunity is found for attacking the difficulties which block the gateways of knowledge. Mathematics, especially if not learned young, are likely to remain unlearned. I will not further insist upon the educational importance of mathematics and science, because with respect to them I shall probably be supposed to be prejudiced. But of modern languages I am ignorant enough to give value to my advocacy. I believe that French and German, if properly taught, which I admit they rarely are at present, would go far to replace Latin and Greek from a disciplinary point of view, while the actual value of the acquisition would in the majority of cases be incomparably greater. In half the time usually devoted, without success, to the classical languages, most boys could acquire a really serviceable knowledge of French and German. History and the serious study of English literature, now shamefully neglected, would also find a place in such a scheme.

There is one objection often felt to a modernised education, as to which a word may not be without use. Many excellent people are afraid of science as tending towards materialism. That such apprehension should exist is not surprising, for unfortunately there are writers, speaking in the name of science, who have set themselves to foster it. It is true that among scientific men, as in other classes, crude views are to be met with as to the deeper things of Nature; but that the life-long beliefs of Newton, of Faraday, and of Maxwell are inconsistent with the scientific habit of mind is surely a proposition which I need not pause to refute. It would be easy, however, to lay too much stress upon the opinions of even such distinguished workers as these. Men who devote their lives to investigation cultivate a love of truth for its own sake, and endeavour instinctively to clear up, and not, as is too often the object in business and politics, to obscure a difficult question. So far the opinion of a scientific worker may have a special value; but I do not think that he has a claim superior to that of other educated men to assume the attitude of a prophet. In his heart he knows that underneath the theories that he constructs there lie contradictions which he cannot reconcile. The higher mysteries of being, if penetrable at all by human intellect, require other weapons than those of calculation and experiment.

Without encroaching upon grounds appertaining to the theologian and the philosopher, the domain of natural science is surely broad enough to satisfy the wildest ambition of its devotees. In other departments of human life and interest true progress is rather an article of faith than a rational belief; but in science a retrograde movement is, from the nature of the case, almost impossible. Increasing knowledge brings with it increasing power, and great as are the triumphs of the present century we may well believe that they are but a foretaste of what discovery and invention have yet in store for mankind. Encouraged by the thought that our labours cannot be thrown away, let us redouble our efforts in the noble struggle. In the Old World and in the New recruits must be enlisted to fill the place of those whose work is done. Happy should I be if, through this visit of the Association, or by any words of mine, a larger measure of the youthful activity of the West could be drawn into this service. The work may be hard and the discipline severe, but the interest never fails, and great is the privilege of achievement.

THE TELEPHONE AND THE POST OFFICE.

A special meeting of the Glasgow Chamber of Commerce was held on Monday afternoon for the purpose of hearing a statement and suggestions by Mr. William Alexander Smith in reference to the telephone companies and the Post Office. Mr. J. M'Laren presided. We take the following report of the proceedings from the *Glasgow Herald*:—

The CHAIRMAN said that at the last meeting of the Chamber he stated that he had had a communication from Mr. W. A. Smith in regard to the Post Office telephonic arrangements, asking him to bring the matter before the directors. It was thought at the time that as Mr. Fawcett had the matter under consideration, and had promised to make a statement in the House of Commons on the subject, it was not desirable that any representation should be made. Mr. Fawcett had since made his statement, which was considered generally satisfactory. But Mr. Smith had had another interview with the convener of the Home Committee, the result of which was that a meeting of the committee was convened. At that meeting the subject was discussed, and it was thought that Mr. Smith had made out a sufficient case for calling the directors together. The present meeting had accordingly been called for the purpose of hearing Mr. Smith, and of coming to any resolution that might be thought desirable.

The SECRETARY then read the minutes of the meeting of the Home Committee, which recommended that the directors should agree to the ollowing resolutions:—"The directors of the Chamber, while viewing with satisfaction the liberal nature of Mr. Fawcett's proposals in regard to the use of the telephone in this country, after experience of which it is earnestly hoped may in future enable further facilities to be conceded without loss of revenue to the Post Office Department, respectfully submit for Mr. Fawcett's consideration—first, that the charging of a royalty of 10 per cent. on the rentals of private lines should not be insisted on, in respect that it places an undue burden upon the use of the telephone; second, that the running of wires between the Post Office telegraph stations and telephone exchanges for the purpose of receiving and despatching telegrams to and from subscribers to such exchanges should be sanctioned and encouraged, and that in all cases where telephone companies are prepared to bear the cost of such wires and guarantee to the Department due payment on telegrams so transmitted, no burden should be imposed on this facility to the development of the Post Office revenue."

Mr. KING, the convener of the Home Committee, in moving the adoption of the minute, said that Mr. Smith made a long statement to the committee, and recommended that the directors should memorialise Mr. Fawcett on the two points embraced in the resolution while the matter was still in dependence, and before the regulations for the future working of the telephone were reduced to writing. It seemed to the committee that by adopting these resolutions the committee would be taking a step which would likely be attended by a good result, inasmuch as the sanctioning of the connection of the wires of subscribers to the exchange with the telegraphs would involve no loss of revenue to the Telegraph Department, but was rather likely to be in its favour. On the other hand it was a new proposal on the part of Mr. Fawcett to impose a tax in respect of private wires, the revenue from which had hitherto been untaxed. Mr. Fawcett did not seem to be very strong on this subject, because in making the proposal that the royalty should be extended to private wires he said the object was not so much to increase the revenue as to simplify the accounts. If this was the sole purpose of the tax he thought it would be easy to make such arrangements as would satisfy him that the returns were just returns, and that they could be easily checked.

The minute was thereafter adopted, and it was agreed that Mr. Smith should be heard.

Mr. SMITH was accordingly introduced, and addressed the meeting. Having referred to the resolutions which the committee had agreed to recommend for adoption, he said it was almost necessary that he should in the first place allude to the royalty that had hitherto been paid by the telephonic companies to the Post Office. That royalty amounted in all to 10 per cent. on the gross receipts—a very large sum. It might be said that this was a matter with which the Chamber had nothing to do, that it was a question entirely for the telephone companies. But in the offer which he made to the Postmaster-General he distinctly stated that whatever reduction of royalty might be granted would be entirely given to the public. He was not speaking for the companies, but for the public, as would be seen when he had said that this royalty amounted to the profit on more than double the nominal increase of all the telegraphic messages in this country, or to more than 5s. in the £ of the net earnings of the companies. Were anything like the same tax imposed upon other industries, such as railways, it would be sufficient in the case, for example, of the North British Railway Company to sweep away all the dividend on the ordinary stock, and to leave them short of money to pay their preference dividends. The reason why he asked them to consider the question in a manner that might appear urgent was that Mr. Fawcett had not said his last word upon the question. He had been good enough to indicate that he would consider the two important points on which he (the speaker) had asked the Chamber to move; and they would readily understand that after Mr. Fawcett's final statement it would be almost impossible for him to move. The point to which he desired to call attention was that the Telephonic Exchanges should be connected with the central telegraph system of the Post Office. Mr. Fawcett, in all the arguments he had urged against the proposal, had said that he must protect the public revenue, that he was trustee on behalf of the Post Office, and that having bought the telegraphs he must make them pay, no matter how private industry might languish. But this particular demand was one that could do nothing but bring the Post Office net revenue. Another reason why he asked the Chamber to move in the matter was that about three years ago he submitted to St. Martin's-le-Grand an offer to make the experiment in Glasgow, and in that offer he came under an obligation to pay all the expense of running the wires to George-square, to pay the rental of a room, to pay the cost of the operators necessary to take in the messages, and to guarantee to the Department by depositing £500, £1,000, or whatever sum might be required. Furthermore, he undertook to free them from all liability as to the correct transmission of telegrams so sent through the telephone. The answer he got was that any firm which desired this facility should pay five guineas per annum—the price of 105 messages—and that thereafter they would be allowed to pay for telegrams like any ordinary individual. Of course, they would see that when the expense was to be on the Company, and the revenue was to go to the Government, the Company did not see their way to ask subscribers to pay an additional five guineas per annum. It was useless for Mr. Fawcett or the permanent heads of departments to say that this facility could not be granted. Newcastle had now just what the St. Martin's-le-Grand officials refused to concede to Glasgow three or four years ago. In the Newcastle Exchange there were five or six boxes in which operators sat for no other purpose than taking in telegrams from subscribers to the telephone system. He thought it must be quite clear to all that he had no desire to speak on behalf of the telephone companies. There was no proposal that the companies should receive any portion of the price of these telegrams, although in America they did allow the telephone companies 20 per cent. on the receipts from said companies. The companies were willing to go to the expense of providing their subscribers with additional facilities, hoping to reap an indirect benefit. By what had been called a mere accident of the drafting of an Act of Parliament the Postmaster-General was enabled to substantiate his claim to impose a royalty on telephonic exchanges, but by no Act under the sun could he demand payment of an additional royalty. There was nothing at present enacted to prevent anyone running private telephone wires and ignoring the Postmaster-General altogether. That argument, he thought, spoke for itself. He had only further to ask them to remember that when the telephone was first submitted to the Postmaster-General the scientific heads of the department said it was a mere toy, and of no use at all. The invention was then

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taken up by others, and since its adoption every obstacle had been thrown in the way of its development by the Post Office, not by Mr. Fawcett, but by those under him. Mr. Fawcett had swept away with a liberal hand many of the absurd restrictions placed upon it. But while he had been giving with the right hand he had been taking away with the left, and the additional royalty would amount to fully 25 per cent. more than had hitherto been exacted from the telephone companies. He thought, in the interest of the public, action should be taken at once to get him to forego this additional royalty, which would be just a tax on the public. The telephone companies were not philanthropic companies, they wanted to make money if they could, and the royalty, if imposed, would affect the charges. In conclusion, he repeated that the whole trouble which threatened them was simply the outcome of the fear that the heads of certain departments in the Post Office had of the development of the telephone.

Several questions having been put to Mr. Smith in further exposition of the subject,

Mr. KING moved that the Chamber memorialise the Postmaster-General in the terms recommended by the committee.

Sir JAMES WATSON seconded the motion.

Mr. W. M'EWEN said he did not wish to raise any objection to the motion, but if they were to allow a tax to be imposed on public telephones and to object to a tax on private telephones, he failed to see where the principle applied.

Mr. SMITH said in the one case the Postmaster-General had an Act of Parliament at his back, in the other there was no such Act.

Sir JAMES WATSON thought the fact that it was a new tax altogether put it in a different position.

The resolutions were thereafter unanimously adopted, and the meeting separated.

COMPANIES' MEETINGS.

Pilsen, Joel, and General Electric Light Company (Limited and Reduced).

The third ordinary general meeting of the shareholders of the above Company was held on Thursday, at the Cannon-street Hotel, under the presidency of Sir Rawson W. Rawson, K.C.M.G., C.B.

The SECRETARY (Mr. E. T. Gregory) read the notice convening the meeting, and the report of the directors was taken as read. It stated, *inter alia*, that "The directors are glad to inform the shareholders that they have successfully carried out the first special resolution passed at the general meetings held in March last, and they congratulate them on the fact that the 11,530 fully paid shares owned by the Union Company, and 370 out of the 470 held by other parties, are now surrendered, leaving only 100 fully paid shares on the register. This relieves the Company from a heavy liability, and is practically a large reduction, amounting to 60 per cent., off the price originally paid for the patents. The second special resolution, viz., to reduce the liability on the partly paid shares by £1, is being carried out as rapidly as the legal formalities will admit."

The CHAIRMAN: In moving the adoption of this report, I think I shall consult your convenience by not detaining you with any long remarks. The Board have carried out the intention which they expressed at the last general meeting, that they would carry on the business of the Company to the best of their ability for another year in the expectation of being able, during that time, to place the business of the Company on a sound and profitable basis, and that if they failed to do that they would come to the shareholders, lay their case before them, and leave them to decide, with the more extended view which they may have of what is likely to occur in the electrical world, whether the Board should continue to carry on the business, or should adopt measures for limiting the expenditure and avoiding further loss of money. The Board deplore with you the result of last year's working. It has not been from any negligence or inattention on their part. They have done their best in the interests of the Company. They have devoted their time and their best services to the shareholders without any reference to personal considerations, at a very great expenditure of time, and, I can assure you, with a very large expenditure of anxiety. We have done our best, but the impediments to success in electrical work you are all familiar with, I am sorry to say, by the failing of so many other companies, whose example in many respects I hope we shall not follow. We have, however, evidence of the difficulty of companies carrying on electrical work with a profit at the present time. We anticipated when we met last year that the public during the winter would have set their minds again on electrical work, but, as we have stated in our report, the difficulties created by the Act of Parliament, the existing state of trade, the general depression, and the indisposition of persons to involve themselves in new and uncertain expenditure, have all combined to hinder their having installations during the last winter. At the present time there is a better prospect, but not such a prospect as would induce us at once to embark in any new installations with a risk of involving the shareholders in further expenditure, and rendering it necessary to call upon them for a further contribution. The directors were, we believe, in entire harmony with the shareholders that it is not expedient to take any action which will incur the risk of a further call. The last call was made for the purpose of carrying out a special object, a most important object, agreed to by the shareholders unanimously in March—to reduce the liability towards the fully paid shareholders. We have succeeded in completing that arrangement, and the shareholders are entirely free from any obligation beyond the balance of the debts which they owed on the 30th of June and the credits which they possessed at the same date. The total indebtedness at that time was stated at about £4,000 and our credits at about £3,000, and consequently the Company is at present liable upon its existing assets to the extent of £1,000. Therefore, under these circumstances, we see that we can save the shareholders from any risk of further calls if they combine with the directors in the action that we have proposed. We have laid before the shareholders with perfect frankness and honesty the exact position of the Company. We have also, after the best consideration that we could give, suggested a line of policy which we believe our shareholders are prepared to adopt. We hope they will act with us to-day in this matter by adopting that policy as set forth in the report. I wish to say one word personal to myself. At our meeting in March I said I saw a rift in the clouds —that I believed at that time there was a chance of our being able to carry on the business at a profit before the winter. I must confess my thorough disappointment in that matter. I do not see at the present time the prospect of our carrying on with the capital already expended—the chance of our being able to do a business which will yield a profit and a dividend for the shareholders; and therefore it is better that we should make the arrangement here suggested, to cut down expenditure, to avoid all future expenditure, until there is some opening, and if there be no opening, that we should come and tell you so. We are united with the shareholders in our determination not to involve the risk of a further call. I believe—and I think most of my co-directors are firmly of that opinion—that there is a future for electric lighting, and that that future is hastening on. We believe that the work of the last two years by our own Company, and by other companies, has cleared the way of many of the difficulties attending upon the installation of electric lighting. We believe that electric lighting may be carried on not only successfully, but also profitably. It will, however, require a great deal of management, and a great deal of economy, it will require a much cheaper factory than we have been involved in from the beginning; it will require a much more simple organisation than that under which we exist to secure a profit. For these reasons we have suggested that we should stop all expenditure, that we should have a limited—a smaller—number of directors to look after the affair, that we should try and engage other capable persons to carry on what necessary business we are under obligation to execute—namely, our contracts for installation, so that we may not be required to keep up a factory and the expense of engines and staff there; and we believe that, adopting that course and waiting for the development of electric lighting, we may still be able to save a considerable sum for our shareholders. Upon these grounds we come with considerable confidence—having communicated with many of the principal shareholders—before you with the proposals which you will have to consider to-day. There is one matter I ought to have mentioned. There is an omission in the report—that General Hopkinson, who was one of our original directors, resigned his seat a year ago, after our first meeting, and we did not consider it expedient to fill up his place. His engagements prevented him from giving any very regular attendance to our affairs, and he was not very sanguine as to the prospect of success. Although we regretted exceedingly the loss of his very valuable advice and support, we were obliged to accept his resignation. The report mentions that one of our directors has not the same view as ourselves with regard to the course to be adopted. Mr. Fellows, who has devoted a great deal of attention to the work of the Company, and who has been most regular in his attendance both at the Board and the factory, having looked into the business of the factory with great diligence and very great interest, does not agree with us as to the policy of our placing our seats at the Board at your immediate disposal; nor does he believe that he is bound to do so under the circumstances attending the modification in that article of our Articles of Association. We believe that it was intended that our continuance in office should be limited to the year 1884; but Mr. Fellows is of a different opinion. He believes it was intended that it should be limited to the year 1886, and he has thought it his duty to continue in his position, although his colleagues, taking a different view, have thought it their duty to tender their resignation; in fact to resign at the present meeting, for the purpose of enabling you to make such appointments for the future direction as may insure your confidence. Though we believe we have not forfeited your confidence, yet we wish to have the renewal of it by the nomination of those gentlemen, either in or out of the Board, who in your opinion would be most likely to carry on the business for your advantage. With these remarks, I move:—"That the report and the general accounts for the past year be adopted."

Mr. HORACE W. SCRIVEN seconded the motion.

Mr. JOEL stated that the directors in the report had expressed their belief that "no company has fared better in this country than ourselves." He, however, thought that the Anglo-American Company, by good management, had fared better than this Company, which, however, he believed had practically the best lamp in the market, and which, he thought, started better than any other company. Moreover, there was no Stock Exchange speculation in connection with the Company, and he contended that they might have done better. Private firms had done a great deal of electric work, and successfully, and in fact though there had been a considerable amount of work to do this Company had not done it. In the previous year there was a turn over by the Company of £3,000, and a loss of £6,000, and in the past year there had been a turn over of £6,000 and a loss of £11,000. His opinion was that that loss had been incurred because the directors had ignored technical assistance, and had tried to conduct a technical business without technical advice. He had been asked to resign, and had parted from the Company for the last 18 or 20 months. Holding 600 shares in the Company, he felt that it was very hard that he had not been allowed to assist in the work it had to do. He felt sure that had he been adviser to the Company as their managing engineer, the loss of £11,000 would not have

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been incurred. They had colonial patents all over the world, but, as far as he knew, nothing had been done with them. He was in favour of all manufacturing business being given up by the directors, the closing of the factory and the office, and the manufacture of the patents on royalties. He then asked a series of twelve questions, and afterwards stated that at their first and second meetings it was said that the money to be spent on experiments would be reduced to a minimum, though he had reason to believe that a great deal of money had been spent in that manner. In the original prospectus a long list was given of the employers of the Pilsen lamp. He had written to all of them, and had asked their opinion of the lamp. In reply he had received 35 letters, out of which 33 were splendid testimonials.

After a few observations from Mr. BLAYDON,

Mr. QUILTER expressed his opinion that the facts stated in the present and the preceding reports had demonstrated that under the present condition of affairs the Company stood very little chance of making a profit. A previous speaker had said that the Company had suffered from the want of technical advice, but he himself was interested in companies now where there had been too much technical advice. As to the future of the electric light, they still believed in it, their faith being only lost in the mode in which they were at present trying to bring out that future. The Legislature had clearly made a great error in the restrictions it had imposed on electric lighting companies.

Mr. J. ROSS warmly expressed his belief in the Pilsen lamp, and said he believed there was a chance of ths Company living, and at no very distant date.

Mr. BELFOUR asked a question as to the item of arrears of calls, £8,261.

The CHAIRMAN, replying, stated that the interest on the arrears had been paid. A considerable portion of the arrears had been paid since the 30th of June. He could not say that all the arrears were good. As to the first call, the amount raised had been beyond their expectations. As to Mr. Joel's questions, that was neither the time nor the place to give a reply to them; nor could the shareholders be judges between the Board and Mr. Joel on many of the points raised by that gentleman. He must say that they had not found what was called technical advice of so much advantage to the Company as to enable them to dispense with practical judgment and sound economical administration.

Mr. JOEL said that as a shareholder he was interested in replies being given to his questions.

The CHAIRMAN asked how Mr. Joel could expect an answer to a series of twelve questions, each of which would require ten minutes to reply to, and without any notice having been given that such questions were going to be put.

Mr. QUILTER stated that for his own part he would object to some of the questions being replied to at a public meeting.

The CHAIRMAN stated that he would be glad to give Mr. Joel every reasonable answer to his questions, but not at that meeting.

Mr. SCRIVEN maintained that Mr. Joel should have sent in a notice to the directors that he was going to put the questions which he had submitted. The directors had always employed the best technical talent they could obtain, and he thought the chief cause of disappointment to Mr. Joel had been that they had not considered that his was the best advice of the kind which they could obtain.

The CHAIRMAN then put the motion in the usual way, and declared it carried on the show of hands.

Mr. EDWARD ELLIS, to assist in carrying out the proposals which had been made by the directors, moved a resolution to the effect that the number of the directors should be reduced to four, or, if Mr. Fellows continued in office, five.

Mr. RAWSON seconded the motion, which was carried.

Mr. ELLIS next proposed that the four gentlemen to be appointed as directors on the new Board (besides Mr. Fellows) should be Sir R. W. Rawson, Mr. Scriven, Mr. Alfred Parrish, and Mr. N. Whateley.

The motion having been seconded,

Mr. QUILTER argued that it would be better only to fill up three of the seats instead of four, observing that he did not know Mr. Whateley, against whom, however, he had nothing to say.

Mr. ELLIS stated that Mr. Whateley had acted on the committee of shareholders for the last eighteen months, and had assisted in carrying out a great many of the proposals which had been placed before the shareholders, and principally the one of reducing the paid-up capital and cancelling the paid-up shares.

Mr. D. PARRISH (a director) supported the election of Mr. Whateley.

Mr. QUILTER moved as an amendment, "That only three directors be elected at the present meeting, and that the remaining vacancy be filled up afterwards and subject to the shareholders' approval at their next meeting."

Mr. BARKER seconded the amendment, which was carried, 13 voting for it and 11 against.

It was next resolved that Sir R. W. Rawson, Mr. Scriven, and Mr. Alfred Parrish should be the three gentlemen appointed.

On the motion of the CHAIRMAN a resolution was passed rescinding article 86 of the Articles of Association, fixing the remuneration of the directors at £1,500 a year. Continuing, the Chairman stated that he was informed by the legal adviser of the Company that there remained nothing to be done now but to pass a resolution adjourning the meeting. He therefore moved: "That this meeting be adjourned to the 12th of September at half-past one o'clock at the Company's offices, St. Stephen's-chambers, Telegraph-street, for the consideration of the remuneration of the Board of Directors and the election of auditors for the ensuing year."

The motion was seconded and carried.

A SHAREHOLDER then proposed, and Mr. BELFOUR seconded, a resolution asking Mr. Fellows to resign.

Mr. FYFE objected to such a request.

The SOLICITOR stated that Mr. Fellows could be put out of office by an extraordinary resolution, of which, however, notice must be given, which had not been done. The resolution, therefore, would have no legal effect.

The resolution was put by the Chairman and declared carried.

A vote of thanks to the Chairman was next passed, and the proceedings then terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. AUG. 27.		BUSINESS DONE WEEK ENDING AUG. 27. Highest.	Lowest.
Anglo-American	30½,	31⅛	31½	31⅛
Do. Preferred	55,	56	56½	55½
Do. Deferred	7,	7½	7¼	—
Brazilian Submarine	10½,	10¾	10¾	10½
Cuba	10¾,	11¼	10¾	10½
Do. Preference	16½,	17½	17½	—
Direct Spanish	4½,	5	—	—
Do. Preference	14¼,	15¼	—	—
Direct United States Cable	9⅞,	10⅛	10¼	10
Eastern Telegraph	11¼,	11½	11 7-16	11¼
Do. 6 per Cent. Preference	13,	13½	13½	13
Do. 5 per Cent. Debentures, 1899	103,	106	--	—
Eastern Extension	11½,	11¾	11 11-16	11½
German Union	9¼,	9¾	—	—
Globe Telegraph and Trust	6⅝,	6⅞	6 13-16	6⅝
Do. Preference	12½,	12¾	12 11-16	12½
Great Northern	13⅜,	13⅝	13⅝	—
Indo-European	31,	32	32	—
Reuter's	8,	8½	8⅜	—
Submarine	165,	175	168½	165
West India and Panama	⅞,	1⅛	—	—
Do. 1st Preference	7¼,	7¾	7½	7 5-16
Western Brazilian	6⅜,	6⅝	6½	6⅜
Western Union 7 per Cent. 1st Mortgage	123,	125	—	—
Do. 6 per Cent. Sterling Bonds	102,	106	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	3-16,	5-16	¼	—
Oriental	⅛,	⅜	⅛	—
United Telephone	11½,	12	11¾	11 7-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1¾,	2	1 13-16	—
Do. (fully paid)	3¼,	3¾	—	—
Hammond Light (£3 15s. paid)	⅝,	⅞	⅝	—
Swan	—	—	—	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	33,	34	33½	33
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23½	—

Pocket Size, 504pp. With Numerous Diagrams. 7s. 6d.

AN ELECTRICAL POCKET BOOK

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NOTES.

ANTI-BURGLAR ELECTRICITY.—The Brussels mail carts are now provided with electrical alarms, which give immediate warning to the driver of any attempt to get at the contents.

SCIENTIFIC CONGRESS.—The meeting of the Association Française pour l'Avancement des Sciences commenced at Blois on 4th inst., under the presidency of M. Bouquet de la Grye; and the session will last until the 14th.

PHILADELPHIA EXHIBITION.—The International Electric Exhibition was opened in Philadelphia on Tuesday. The British Government was represented at the opening ceremony by Captain H. R. De Wolski, of the Royal Engineers.

THUNDERSTORM.—On Tuesday last Dundee and the surrounding district was visited by a thunderstorm of considerable violence. A heavy hailstorm followed; the stones were exceptionally large, many of them being a quarter of an inch in diameter.

ELECTRIC LIGHT at NUREMBURG.—We learn that, besides Herr Brunner's bank and several shops, the Royal Industrial School is soon to be provided with a complete system of electric light. A central station with Schuckert machines is also in construction.

ELECTRIC LIGHT AT LEIPSIG.—It is reported that the electric lighting of the Mars-la-Tour panorama at Leipsig has been given to the Brush Company, whose price was £300 lower than that of Siemens, Fein, and others. The Brush Company have undertaken to supply from 10 to 16 arc lights with a dynamo and a steam engine for £500.

THE ELECTRIC LIGHT AT THE BRITISH MUSEUM.—It appears that the electric lighting in the reading room of the British Museum has been so far improved, in the direction of securing greater steadiness, as to stop the complaints that were so rife, and also to cause the attendance of a progressively larger number of readers in the evening.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of August was 2,916, estimated to produce £2,375, against 2,470 messages, producing £2,315 in the corresponding month of last year. The traffic receipts for the month of May, estimated at £2,950, realised £2,973.

ELECTRIC ILLUMINATION OF THE ACROPOLIS AT ATHENS.—A grand effect is reported to have been produced by the judicious disposition of a few electric regulators on the highest points of the Acropolis at Athens. In this way not only was the Acropolis itself illuminated, but the light was also thrown on the various temples and other ruins that surround it.

THE ELECTRIC LIGHT AND AMBULANCE OPERATIONS.—It is reported from Geneva that some experiments have been made by the Red Cross Societies with the electric light, the object being to demonstrate its usefulness after a battle in facilitating search for the wounded, and also the burying of the dead. The apparatus used was drawn by two horses only.

UNIVERSITY COLLEGE, BRISTOL.—We notice that special arrangements are made by the college for those who desire to study in order to make themselves proficient as electrical engineers. The special courses more particularly relate to electric lighting, transmission of power, telephony, electrolysis, &c. These special courses are under the direction of Professor S. P. Thompson.

LEGAL.—In the case of Saunders and Son *v.* The United Telephone Company, the defendant company submitted to a perpetual injunction restraining the company from stretching, placing, or affixing over or upon, or to the roof or other part of the warehouses of the plaintiffs, situate in Cannon-street or Budge-row, any overhead wires. Mr. Oswald appeared for the plaintiffs, and Mr. Crosskey for the defendants.

THE LATE MR. SCUDAMORE.—The will (dated Feb. 2, 1883) of Mr. Frank Ives Scudamore, C.B., formerly of the General Post Office, but late of Therapia, Constantinople, who died on Feb. 8 last, was proved on the 23rd ult. by Sherwin Scudamore, the value of the personal estate exceeding £5,000. The testator leaves all his real and personal estate to his wife, Mrs. Jane Ellen Moore Scudamore, absolutely.—*Illustrated London News.*

CHINA.—The Eastern Telegraph Company notifies that in consequence of hostilities having commenced at Foochow, telegrams for this place can only be accepted at the sender's risk to go from Shanghai by Chinese Government land lines, at the rate of 10s. per word. The company also notify later the interruption of the Chinese land lines beyond Chining, thus cutting off telegraphic communication with Tientsin and Pekin.

ELECTRIC LIGHT FOR FRENCH LIGHTHOUSES.—The luminous intensity of the forty electric lighthouses which are to be placed on the French coast has been calculated so as to secure, during ten months of the year, an illuminating power that oil lighting only effects during six months. To obtain this result, the light must be equal to 125,000 carcels—say 1,250,000 candles—a luminous intensity that neither oil nor gas can supply practically.

AN EMPIRE WITHOUT A CROWN.—There is only one thing wanting in the magnificent Empire Theatre, opened in Leicester-square a few months ago; and that is the electric light. But we are informed that, after the experience of the late sultry weather, this desideratum will be supplied by next summer. As it is, the glass flowers of the gas brackets are remarkably suggestive of incandescent lamps; and there is an electric call from the stage to the handsome *foyer*.

GREAT NORTHERN TELEGRAPH COMPANY.—The Chinese Telegraph Administration notifies that from 1st September until further notice private telegrams to stations on the Chinese land lines (Pekin, Tientsin, Hankow, Foochow, &c.) must be written in plain English language. Commercial telegrams in code or cipher are not accepted. The above restrictions do not refer to neutral Governments' telegrams nor to telegrams to the cable stations, Shanghai, Amoy, and Hong Kong.

EARTHQUAKE IN LOWER AUSTRIA.—A shock of earthquake was felt on Monday last at the watering places of Baden, Voeslau, and Gainfarn, in Lower Austria. It extended over a distance of ten miles in a south-easterly direction as far as Weiner Neustadt. The tremor was so strong that the congregation in a church at Weiner Neustadt, in which service was proceeding at the time, were panic-stricken, and rushed out of the edifice. The thermal springs at Voeslau experienced a marked rise in temperature during the shock.

THE TOWN HALL, BIRMINGHAM.—During the forthcoming concerts to be held in this hall, the electric light will be used.

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It will be remembered that great pains were taken to discover the ideas of performers as well as listeners as to the acceptability of the electric light, with a general concensus of opinion in its favour. The replies have been published by Messrs. Winfield and Crompton, and were referred to by Mr. Crompton in his recent paper at the Health Exhibition. The lighting will be carried out by Messrs. Winfield and Crompton, as before.

ELECTRIC LIGHT IN THEATRES.—The Paris Châtelet, noted for its splendidly mounted extravaganzas, is to be added to the list of theatres in which electricity supersedes gas for illumination. It is said that considerations of safety have, in this case, had quite as much to do with the decision as a desire for increased effect. The works are already in progress, the steam engine for driving the dynamos being already erected. Incandescent lamps are used on the stage of the Berlin Opera House; but the project of illuminating the auditorium has been indefinitely postponed.

THE MIDLAND BRUSH COMPANY.—The following appears in the *London Gazette* of Sept. 2:—"Notice is given that the Brush Midland Electric Light and Power Company (Limited and Reduced), at extraordinary general meetings held on the 28th of November and 24th of December, 1883, passed a special resolution reducing its capital, which was confirmed by an Order of the High Court of Justice, Chancery Division, bearing date the 28th day of July, 1884, and the said Order was, pursuant thereto, duly registered with the Registrar of Joint Stock Companies on the 20th day of August, 1884."

TELEGRAPH LINE TO BOKHARA.—*The Times* correspondent from St. Petersburg writes that it is rumoured permission has been given to extend the Russian telegraph system from Katta-Kurgan to Bokhara. The Ameer had previously refused his permission. In any case, the union of Tashkend and Bokhara by telegraph is regarded by the Russians as a very important matter for Russian commerce as well as Russian policy. Competition on the Bokharan markets with English goods brought by way of India will be immensely promoted and facilitated, think the Muscovite merchants, by this telegraphic advance, and the Russian Government will possess a telegraph outpost in Bokhara of great importance.

ELECTRICAL EXCURSION TO AMERICA.—The scientific mission organised by Dr. Cornelius Herz, of *La Lumière Electrique*, started from Havre for New York about a week ago. The party, which consists of Messieurs Abdank-Abakanowicz, Bertrand, G. Duché, Auguste Gnerout, O. Kern, and D. Napoli, will remain at Philadelphia during September to study the Electrical Exhibition. It will then split up into several sections, which will traverse the United States as far as San Francisco, and also Canada, in order to obtain materials for a work on the industrial application of electricity in America. The members are to meet at New Orleans, whence they will proceed to Havana, so as to return to France by the end of the autumn.

TELEPHONE COMPANIES AND THE POSTMASTER-GENERAL.—The Postmaster-General has notified to the various telephone companies that he is now prepared to issue licenses in conformity with the concessions announced in the House of Commons on the 7th of last month. In addition to these important concessions, he has also conceded to the telephone companies the privilege of connecting the various telephone systems with the postal telegraph offices, thus enabling telephone subscribers to transmit telegrams directly from their own offices to any part of the United Kingdom or abroad free of any extra charge. The Postmaster-General has also abandoned his claims for a royalty of 10 per cent. to the State on all private wires.

OVERHEAD WIRES ON PRIVATE PROPERTY.—Advices from York state that, in the recent case heard before the County Court judge, between Mrs. Gutch, of Holgate Lodge, and the Postmaster-General, the former objected to the placing of overhead wires and posts in her park, on the ground of their unsightliness, their obstruction of light from lamps, and the singing of the wires when agitated by the wind. Her request that the wires might be carried underground had been refused on the score of expense. As the result of arbitration, the Postmaster-General has been authorised to place and maintain telegraph posts and wires along the north-east of the road leading from York to Boroughbridge as far as the passes by the side of Holgate Lodge, but the wire is to be only one-third the diameter of that generally used.

THE ELECTRIC RAILWAY AT EDINBURGH.—At the recent visit of the Prince and Princess of Wales to the Forestry Exhibition, Edinburgh, says the *Jewish World*, "Mr. Binko (a co-religionist), the patentee of the electric railway, was introduced by the Marquis of Lothian. Mr. Binko had the honour of explaining to their Royal Highnesses the mechanism of the the railway and the manner in which the cars were propelled. The royal party ventured to travel in the electric car which had been especially prepared for them by the inventor, the ingenious appliances of which greatly interested them on their alighting. Miss Binko presented the Princess of Wales with an electric bouquet. Mrs. Binko also presented the Princess Louise with a similar bouquet."

PATENTS FOR INVENTIONS.—A Parliamentary return shows that the number of applications for letters patent during the year 1883 was 5,993, being 248 less than the preceding year. On these applications there were 3,958 letters patent sealed, but, deducting 63 letters patent, the patentees having neglected to file final specifications in pursuance thereof, there remained 3,895 letters patent in force. A table giving the results of applications for the year 1852 shows that about 65 per cent. of the applications for patents from that year to 1883 became valid; that of the valid patents obtained upon the applications from 1852 to 1876, 30 per cent. paid the third year's stamp duty of £50, and continued in force to the end of the seventh year; and that about 10½ per cent. paid the seventh year's stamp duty of £100, and consequently remained in force for the full term of fourteen years.

TRAMCAR DRIVEN BY ELECTRICITY.—Mr. Holroyd Smith's system of electric tramway, which was described and illustrated in our columns (Vol. XI., p. 487), was tried lately at the Cornbrook Telegraph Works, Manchester, where the plant has been constructed. The car ran along a temporary track laid down in a field near the works, and was perfectly under control, the motion being very smooth and even. The current was obtained from a Siemens generator at the works. Mr. Smith believes he has overcome the difficulty of keeping clear the centre track, along which runs the instrument for collecting the electricity from the continuous conductors and transmitting it to the dynamo in the car. He has also devised means for minimising the difficulty caused by an accidental breakage of the collector. It is calculated that the working expenses with this system will be 2d. per car per mile, as against 10d. for horse traction.

ELECTRIC MOTOR FOR STEERABLE BALLOONS.—The great difficulty in propelling and directing the course of balloons has been hitherto the impossibility of obtaining a motor of suf-

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ficient power commensurate with the requisite lightness. But it seems, according to a letter from Kiel, published by the *Cologne Gazette*, that Dr. Woelfert has made two successful attempts at aerial navigation with a balloon, cigar-shaped, like that of Captain Renard, driven by a special electric-motor only one-fourth the carrying capacity. The contents of the trial balloon is 500 centimetres or 17,658 cubic feet. Inflated with ordinary lighting gas it will carry a load of 350 kilogrammes or nearly 7cwt.; but filled with hydrogen it will lift more than double that weight. One of the voyages lasted two and a half hours, during which Dr. Woelfert is said to have made his way against a north-east wind blowing from two to three metres, or 6½ft. to 10ft., per second.

THE "ST. JAMES'S" ON MR. FAWCETT'S CONCESSIONS.—Mr. Fawcett's concessions to the telephone companies, says the *St. James's Gazette*, go rather beyond what he foreshadowed in the House of Commons, and are good as far as they go. The companies are to pay 10 per cent. upon their gross receipts, except for private wires, and permission is given for the wires of the companies to be connected with the post offices. On the other hand, every telephone company must obtain a licence, the granting or refusal of which is entirely within the discretion of the Post Office, and the latter will not at any time admit any obligation to give way-leave over its own wires to, or erect new trunk wires for, the companies. "There is no doubt that the use of telephones will," in the opinion of the above-named journal, "remain less general, and therefore less beneficial, in consequence of the monopoly given by statute to the Post Office, than it would be if the companies were permitted to carry on their business free from any restrictions."

A TELEGRAPH WANTED.—The other day a deputation from the inhabitants of the Upper Hastings and Manning district waited upon the Hon. J. Norton, Postmaster-General, New South Wales, to urge the establishment of some system of communication, telegraphic or telephonic, between that district and Sydney, by way of Port Macquarie. Messrs. J. H. Young and C. J. Roberts, the members for the district, introduced the deputation. Mr. J. H. Young said that the inhabitants of the Upper Hastings and Manning district suffered great inconveniences for want of some system of communication for connecting the various towns and villages on the Hastings River with one another and Port Macquarie. The farmers and those engaged in carrying on the river traffic annually suffered heavy pecuniary losses owing to the absence of telegraphic communication with Port Macquarie. Many of the farmers lost £50 and £100 per year for want of proper means of obtaining prompt and reliable information concerning the markets. The Postmaster-General thought the deputation had made out a good case, and he would give the matter his careful consideration, and, after consultation with the Superintendent of Telegraphs, would see what could be done to meet what seemed to be a deeply felt want.

NEWCASTLE-ON-TYNE.—The electric light formed a prominent feature in the city illuminations on the occasion of the visit of the Prince and Princess of Wales to Newcastle-on-Tyne on August 20th and 21st. Three powerful arc lights, each of 8,000 candle-power, were shown in different parts of the city; one of these was placed in the beautiful lantern tower of St. Nicholas Cathedral, being visible for many miles around. The effect produced was very fine, and much admired by the large crowds which gathered to see it. The light shining through the stone tracery threw dark shadows across the sky, taking the shape of a gigantic cross when viewed from any side of the tower. The other two lights were placed in the principal street, one of them being just opposite to the gas office, where an extensive gas illumination was exhibited. The contrast was very striking, the superior brilliancy and purity of the electric light giving rise to much comment. All these installations were carried out for the different parties by Messrs. J. H. Holmes and Co., electric light engineers, Newcastle-on-Tyne. The same firm has also lighted a polytechnic exhibition at Hetton, co. Durham, for four weeks, by means of 45 Swan lamps and one arc lamp worked in parallel circuit from the same dynamo, with perfect success, attracting large numbers of people to whom the electric light was a novelty.

DEATH OF MRS. EDISON.—A correspondent writes, Will you do me the kindness of inserting the following paragraph in the next edition of *The Electrician*? It is an extract from the *Evening Telegram*, New York, August 12, 1884:—"Death of Mrs. Edison.—Mrs. Mary Stilwell Edison, the wife of Thomas A. Edison, the electrician, was buried this morning at Menlo Park. Her remains were placed in a casket, which rested in the centre of the parlour. Around it were ranged many beautiful floral tributes, while cut flowers were strewn on the remains and on the floor underneath. Shortly after eleven o'clock Mr. Edison, who had remained in his room, was conducted to the parlour by Mr. Samuel Insull, his private secretary. The doors were closed, and he was left alone with the dead. Intense silence prevailed, which was broken only by the sobs of a strong man. At half-past twelve o'clock the Rev. Mr. Mason, of the Presbyterian Church, Metuchen, New Jersey, entered, and read the funeral service of the dead. At its conclusion the people assembled in front of the casket to take a last look at the face of the deceased. The casket was then closed. The pallbearers, ten in number, forming on either side, with relatives to the number of forty and a throng of friends, the procession moved up to the railroad station, where a train was in waiting to convey the funeral party to Fairmount Cemetery in Newark. There the remains were placed in the receiving vault pending the decision of Mr. Edison as to their final resting place. There were no services at the cemetery. There were present at the funeral many of the representative business men of this city, as well as a number of Mr. Edison's *employés*."

ELECTRICITY VERSUS COMPRESSED AIR.—Mr. Radcliffe Ward writes to the *Pall Mall Gazette*, in answer to Colonel Beaumont's criticism, as follows:—"As the Leytonstone trials were arranged for and carried out by me with a purely experimental car brought from Belgium by Mr. Philippart, I beg to observe as follows:—Colonel Beaumont must know perfectly well that the lumbering, heavy Leytonstone car by no means represents the existing electrical appliances obtainable even in the open market. Colonel Beaumont has no foundation in fact for making the statement that the efficiency was 1 per cent. of the initial power. Those who know anything of the subject are aware that this is an absurd statement to put forward to damage electricity as compared with compressed air. For those who do not understand let me observe that both electricity and compressed air as applied to tramway work act as reservoirs for energy produced from an extraneous source—say, a stationary steam engine. Now, compressed air appliances are both more costly and weigh more than electrical appliances for a given power stored and operated. I believe that Colonel Beaumont claims to run eight miles with one charge on a moderately level road; an electric car has actually run 20 miles in Paris over various grades with one charge. Yet the compressed air car represents the work of years and much money spent on developing it; only a comparatively small amount of time and money has

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been given to the electric car, yet it already runs more than double the distance. However possible, from a purely mechanical point of view, it may be to work the underground trains by ponderous compressed air-engines, such cannot compete for economy with an electric system with electric engines and accumulators."

ELECTRICAL CONFERENCE.—The National Electrical Commission, *Science* states, met in Philadelphia on August 7. It was decided that the Conference to be conducted by the Commission will meet on Monday, September 8, to be then continued from day to day, as may be found necessary. The invitations to the Conference will be confined to physicists of eminence, and to experts in the practical management of electrical appliances and apparatus. It is proposed to extend special invitations to prominent foreign visiting electricians. It was also decided to issue a circular inviting the conferees to submit a paper to be read before the Conference. It is not definitely known what subjects will be discussed at the Conference, but the following matters have been suggested: The sources of electrical energy; the theoretical conditions necessary to the most efficient construction of the dynamo-electric machine for the various purposes of practical work; the electrical transmission of energy; the systems of arc and incandescent lighting; the theory of the electric arc, storage batteries, electro-metallurgy; lighthouses for the coast; applications of electricity to military and mining engineering; lightning protection; induction in telephone lines, and the problem of long-distance telephoning; the question of underground wires; atmospheric electricity; earth currents and terrestrial magnetism; photometry and standards for photometric measurements; the ratio of the electro-magnetic to the electrostatic system of units, and the electro-magnetic theory of light; and finally, on account of the pressing necessity for accurate and uniform electrical measurements, it is probable that the question of establishing a National Bureau of Physical Standards will receive proper attention.

ANTWERP INTERNATIONAL EXHIBITION.—The Lords of the Committee of Council on Education have received information through the Foreign Office that the international exhibition at Antwerp will be a national and governmental undertaking, under the immediate patronage of His Majesty the King of the Belgians. The president of the exhibition will be his Royal Highness the Count of Flanders, and the vice-president the Minister of Agriculture, Industry, and Commerce. The committee will consist of 450 members, and the Belgian Parliament will be asked to vote a sum of money for the commission. The State will nominate the jury and regulate its functions. The exhibition will be opened on May 2, 1885, and will embrace five principal divisions or sections, namely:—1. Education, including the fine arts and art applied to industry. 2. Manufactures. 3. Commerce and navigation, fisheries and pisciculture. 4. Electricity. 5. Agriculture and horticulture, each of which will again be subdivided into groups and classes. The triennial exhibition of painting, sculpture, and architecture, to which artists of all countries will be invited to contribute, will coincide in 1885 with the universal exhibition. The growing importance and favourable geographical position of Antwerp give every reason to hope that the proposed gathering will be largely attended. No effort will be spared to insure the success of the undertaking and to make it worthy of the attention of foreign nations. All necessary measures will, it is stated, be taken on the part of the Belgian Government to protect the patentable inventions, models, drawings, or trade marks which may figure at the exhibition. An influential committee of citizens of Antwerp, under the honorary presidency of the burgomaster, is now actively engaged forwarding this vast enterprise in its various branches.

TELEPHONIC COMMUNICATION FOR MONS, BELGIUM.—The town of Mons is about to be provided with a complete telephone system, in conformity with a convention made in June, 1883, between the Municipality and M. Van Hulle, of Brussels. The latter has given up his rights to M. Kahn, who has entrusted the direction of the work to M. Roder, engineer. The town authorities have given a building for the central office, and also the exclusive right to carry wires over the communal buildings and the less important roads, the Hôtel de Ville, the belfry of the Château and the Collegiate Church of Sainte Waudru being excepted. The concessionaire undertakes to provide twelve gratuitous services for the Municipality, and to accord a reduction of 35 per cent. on the subscriptions of establishments under the control of the City and Provincial Authorities and the Government. The subscription of 150fr. (£6) per annum, is to be reduced by 140fr. (£5 12s.) when the subscriptions exceed 400. The central office, situate in the Rue de la Peine Perdue [*absit omen*] is already arranged for 450 communications. The overhead wires of galvanised steel, fully two millimetres in diameter, are hung on timber frames capable of carrying 100, 140, and even 150 wires. The porcelain insulators are of the type adopted in Switzerland for telephone lines. For lines of long distance, from the central office to the railway station, for instance, the wires are of phosphor bronze, and they are hung on posts. Two tables of communication for fifty subscribers are already placed in the central office. The instruments hitherto fixed in the houses, &c., of the subscribers are carbon transmitters of a type nearly resembling the Crossley or the Ader. Williams's magneto calls are used, fixed on boards, and placed underneath the transmitters. The batteries for actuating the microphones are Leclanché cells with porous vases on connected plates. As a rule, three batteries are reckoned for each subscriber. All the installations have been made with the greatest care, and mainly in view of the great increase of long-distance telephonic communications which is likely soon to take place in Belgium. Like the other chief towns of provinces Mons will be one of the first to be provided with all the instruments included in the Van Rysselberghe system, which will shortly permit the manufacturers and collieryholders of the Borinage [the local name given to the district, otherwise known as the "Couchant (West) de Mons," where the most valuable coal is extracted] to communicate by telephone not only with Brussels and Antwerp, but also with Charleroi, Liege, Verviers, &c.—*Bulletin de la Société Belge d'Electriciens.*

NAVIGATION IN FOGS.—The *Electrical World* of New York suggests the use of telephones to assist in the navigation of vessels during foggy weather. Two telephones are used, one carried on board a small boat acting as a pilot boat, the other on board the ship. Our contemporary says:—"All that is necessary is that the portable telephone reel with one of the telephones shall be carried on board a small ship's boat or steam launch, while the other telephone is retained on the steamer. The small boat can now act as a pilot during the densest fog or on the darkest night. The crew of the small boat or launch can take soundings or other observations, and report at given intervals of time to the steamer with which it is connected by the light telephone cable. Practically, any length of cable can be run out from the telephone reel, but for navigation purposes the boat need only be a few hundred yards ahead.

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The apparatus is so simple that any able seaman can work it. In this way a steamer or man-of-war can pick her road with safety along a rock-bound coast or through the most dangerous shoals and reefs. If it be assumed that the telephone boat propelled by oars or steam makes only five miles an hour, it will be seen that a ship, instead of lying in a fog, can gain at least a hundred miles a day. The expenses of any of the large passenger steamers are enormous, and the saving on a single day would equip a whole fleet with portable telephone apparatus. Those who have seen the apparatus in operation know that it is practical in the highest degree, and eminently adapted to such a use as we now suggest for it. One need not be very sanguine to look forward to the time when every shipowner will regard a portable telephone as an equipment fully as necessary for his vessel as compasses, telescopes, and life-saving apparatus. Although its chief employment at sea may be that above proposed, many other uses will at once suggest themselves to any one familiar with navigation. For instance, a vessel may lie off shore temporarily, taking in cargo or unloading. At such times means of easy and constant communication are a great desideratum. At present the difficulties in the way of frequent intercourse between ship and shore are numerous and often insurmountable. But with a portable telephone apparatus, conversation can be carried on all day long between the two ends, even in the roughest weather and through the night, and much valuable time can be saved. When she arrives at her destination, all that the ship has to do is to send one end of the line ashore. When she leaves, the only thing to be done is to bring that end on board again in any suitable way."

UNDERGROUND ELECTRICAL RAILWAYS.—The following description of a double line electrical railway, at the Oppel Pit of the Zaukeroda Mines, is condensed from the *Jahrbuch für das Berg und Hüttewesen*. It is laid at a depth of 720 metres and in a straight line, being run over by 660 waggons during the two shifts of eight hours each. The rails are of the contractors' type, weighing about 12lb. a yard; and the gauge is a little over half a metre. One line serves for the full waggons and the other for the empties. The electrical traction exists only for a length of 620 metres, the remaining 50 metres being reserved for making up the trains. The dynamo electric machine (Siemens' D 3) and its steam motor are erected on the surface, 63 metres distant from the shaft. The speed of the dynamo is 750 to 850 revolutions per minute, for 225 to 250 of the engine. The conductors consist of (1) from the dynamo to the shaft, two uncased copper wires 6½ millimetres diameter; (2) extending down the shaft, two copper wires of the same diameter, covered with gutta percha, lead, and galvanised iron wires, secured by holdfasts; but in the return wire the outer casing is omitted; (3) in the heading, two lines of rails of inverted T section, fixed to the roof of the heading by means of insulators. The locomotive, which receives the electricity, is connected to each line of T bars by a small metal cable terminating in a contact. These contacts, drawn along by the engine, clip the leads by means of springs, being capable of easily sliding along the bars. The locomotive is 2·53m. long, 0·8m. wide, 1·50m. high, and weighs a little over 1½ ton. Both ends are similar, and are provided with starting, reversing, and brake levers. Along the heading of the mine are also suspended two small uncovered copper wires, in communication with an electric bell in the engine room on the surface. All the driver has to do, in order to make the bell ring, is to press these two wires together with his hand; and this permits, through preconcerted signals, of ascertaining at what point of the journey there is an acceleration, a stoppage, or a re-starting of the locomotive. The trains consist of 15 trucks, containing nearly half a ton of coal. The journey of 650 metres is made in four minutes on an average, corresponding to a speed of nearly 9ft. a second. When the engine-man on the surface becomes conscious of a stoppage of the locomotive through the increased speed of his own engine, he partly shuts off steam; but as soon as he perceives an increased resistance, he turns on some more steam. The locomotive gives out about 46½ per cent. of the energy of the steam-engine, allowing 25 per cent. for the friction of the gear and wheels. The cost of the installation was £812; and the working expenses, for 660 trucks 16 hours a day, 11s. 8d.

THE TELEPHONE ELECTRIC SIGNALS AT THE BRUSSELS LAW COURTS.—The already important telephonic arrangements of the new Palais de Justice, Brussels, have lately been extended, the office of the public prosecutor's *parquet* and the private rooms of the magistrates being provided with telephonic instruments. All the transmitters in the various courts are put in connection with a central switch in the telegraph office. This is intended to place the magistrates in communication with counsel; and the latter, by means of an instrument of the Bell Telephone Company, are able to correspond with the subscribers of the Brussels, Uccle, and Boitsfort (suburbs of Brussels) lines, and will soon be able to hold converse with their brethren of the bar in Antwerp, Ghent, Liege, Verviers, and other towns. The first telephone instruments were of the Ader system, with De Gilliland magneto calls, but the last transmitters just added are much improved, thanks to a new arrangement of carbon and contacts, devised by M. Van Rysselberge. While the external form is not altered the transmitter is fixed to a board, and the magneto call is placed above the microphone. As to the other electrical appliances fixed in the various courts, their choice and arrangement, and the ingenious combinations devised by the officials appointed to direct the works are calculated to interest those connected with the applications of electricity. A few figures will suffice to give an idea of the importance of these installations:—110 electric calls of the Lippens type, that is adopted by the Belgian Government, are placed in the various courts, and correspond with 26 indicators, forming together 88 numbers, which communicate with 164 small pushes. A special conductor has been chosen to connect these instruments. It is so constructed that the copper wire, a full millimetre in diameter, is sufficiently protected to prevent any fear of oxidation through damp, being covered with nearly 2½ millimetres of gutta percha and plaited cotton paraffinned. The total length of the circuit connecting the whole of these instruments is nearly 30,000 metres (98,426ft.), and there are 600 Leclanché batteries. The contract for supplying all the electrical plant was let by public tender, according to a specification drawn up by a special committee nominated by the Department of Justice, and Mourlon et Cie., of Brussels, secured the work. All the clocks, on the Thomas and Bouckaert systems, work by electricity. Moreover, an indicator of the calling of cases, ingeniously arranged by MM. Richez et Hipmann, is placed in the barristers' library, each court being placed in communication with it by means of a self-acting switch. An electric call gives warning of the commencement of the sitting in a court corresponding to the number which is shown at one of the openings of the indicator. All the electrical instruments, as well as the plant necessary for the telephonic installations, have been put down by the *employés* of the Administration des Télégraphes, under the direction of MM. Dery and Dumont, engineers.—*Bulletin de la Société Belges d'Electriciens.*

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THE INDUCTION OF CURRENTS IN CORES.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 363.)

[ERRATA IN LAST.—Page 362, first column, second line after (76), *for* number *read* member; second line from bottom *read* $r\frac{dv}{dr} = n\frac{dv}{dn}$; second column, first line after (82), *for* numeration *read* summation; and in first equations after (81) introduce factor H_0 on right side.]

This equivalence of total heat to initial magnetic energy can of course be predicted beforehand, as a certain consequence of the elementary laws underlying the structure of our solutions for the magnetic force and the current, and therefore its verification merely serves to show that we have not got upon a wrong track in the pursuit of a mathematical wild goose, which may happen unless proper tests are occasionally applied.

Remarks on Normal Systems.—In (82) the magnetic force (and in (83) the current) is expressed as the sum of a number of terms each of which is the product of a function of r, the distance from the axis, into a function of t, the latter being such as to show a decrease in the magnitude of the term with the time in the same manner as the charge of a condenser decreases when discharged through a conductor of insensible self induction; or as the current decreases in a linear circuit of insensible electrostatic capacity and subject only to its own self induction; or as the momentum of a body decreases when resisted by a force proportional at any moment to its momentum at that moment.

Now, as may be seen from the values of the first four A's given below, the series is very slowly convergent at the start ($t=0$), and a large number of terms would then have to be taken to make the sum come to H_0 within, say, a millionth part. But, owing to the different rates of subsidence of the normal systems, the series soon becomes rapidly convergent. The higher ones subside so rapidly that in a short time, before the first has sensibly altered, only it and a few of the following are of any importance, and as time progresses those left drop out of practical existence one by one till at length, before the magnetic force has fallen to half strength at the centre of the core, the first normal system is left alone. The distribution of magnetic force in the core from the axis outward is then represented simply by the curve v_1 in Fig. 2, which continues to be the distribution during the remainder of the discharge, only falling in strength according to the exponential law. Thus, by considering the first normal system only, calculating the values of A and of D belonging to it, we obtain important information, for we know thereby the solution except for small values of the time. But the neglected terms completely alter the character of the subsidence at the commencement of the discharge, as we may see from the value of A_1, viz., $1{\cdot}667H_0$, which is, at the axis, $\frac{2}{3}$ greater that H_0, the real initial strength, and of A_2, which (negatively) is also greater than H_0. This, however, will be made fully evident from the curves of the magnetic force and current at the axis and boundary. The values of the first four A's are

$$A_1 = 1{\cdot}667H_0,\ A_2 = -1{\cdot}065H_0,\ A_3 = {\cdot}856H_0,\ A_4 = -{\cdot}737H_0.$$

The above remarks concerning the great relative importance of the first normal system of slowest subsidence may, to a certain extent, be generalised. Given any arbitrary distribution to start with, the system of slowest subsidence will soon be left decaying alone, all its companions having faded and gone, unless it should happen that one or more of them be of such great initial strength that their influence continues sensible, masking that of the first system. Or, the initial distribution may not contain the one of slowest subsidence at all, or any number of systems may be absent. But in the various practical cases that arise of initial distributions set up by a battery, the system of slowest subsidence has the greatest amplitude, and the amplitude of the others decreases with their rapidity of subsidence. It is easy, however, by suitably arranged boundary conditions, though they may not always be practicable, to introduce various anomalous peculiarities, quite altering the character of the subsidence, or reversing it, making the force increase.

In the above case the roots na are all real, giving real D's. This is, however, not necessary. The n's may be, some or all, imaginary, when, of course, the corresponding normal systems and their rates of subsidence are imaginary. By pairing two connected imaginary terms, the unreal parts mutually cancel, leaving a real dual system which subsides with oscillations instead of in the former manner. In all cases the finding of the proper normal systems is of primary importance, and in all cases their amplitudes, to make up a given distribution, may be found by the magical process of selection of coefficients by the conjugate property of the normal systems, either as above exemplified, or in a similar, though more general manner.

Example 2.—Coil Circuit Closed. Coil of Negligible Depth.

Let the core be charged as before in the first place, and then be discharged by removing the E.M.F. from the coil circuit, but leaving it closed. There will be a current in the coil (the extra current) in the same direction as the original current, and as the induced current in the core. Its effect, we see at once, is to retard the rapidity of discharge, and to keep up the core's magnetisation longer, if it be magnetisable, in the ordinary sense. The theory makes no distinction between iron and any other metal, except in the value of the coefficient of magnetic permeability. In the last example the boundary condition which settled the values of n and D was $H_a=0$, because there was no current outside the core, the coil current being stopped. (We disregard dielectric currents, to be later considered, as they are of utterly insignificant magnitude in comparison with the conduction currents in coil or core.) Now, there being a current in the coil, the boundary magnetic force is not zero, but stands in a constant ratio to the coil current. The coil current again is proportional to the boundary E.M.F. of induction, and therefore, by Ohm's law, to the boundary core current. Hence the boundary magnetic force and the density of the boundary core current are constrained to preserve their ratio constant during the whole period of the discharge, and the same is true for every normal system of magnetic force with its accompanying current. Determining the value of the constant by (15) and (20), taking a = radius of core filling the coil, and the depth of coil small compared with a, and putting $E=0$, since there is no externally impressed force, we have

$$0 = H + sH'. \quad \ldots \quad (88)$$

where $s = L\rho/2\pi\mu aR$, L being the coefficient of self-induction, R the resistance of the coil circuit, ρ the specific resistance, and μ the permeability of the core.

Put $J_0(nr)$ for H in (88), and we obtain

$$0 = J_0(nr) + s\frac{d}{dr}J_0(nr), \text{ at } r=a.$$

Or, $$J_0(na)/J_1(na) = sn, \quad \ldots \quad (89)$$

by (73). In Fig. 1, giving the curves of J_0 and J_1, we must find the values of na satisfying (89), instead of the places where $J_0=0$. The effect is to shift the position of all the roots to the left, through different distances, say, as in a calculated case, from B_1 to C_1, B_2 to C_2, &c. The value of n_1a is reduced in a far greater ratio than n_2a, &c., and since the time constants of the normal systems vary inversely as $(na)^2$, the effect is to make the first system of still greater relative importance than before.

In the case to be illustrated, I have taken $s=1$ and $a=1$, which corresponds to not unpractical coil data. The determinantal equation (89) is then $J_0(n) = nJ_1(n)$; or, in full,

$$0 = 1 - \frac{3n^2}{2^2} + \frac{5n^4}{2^2 4^2} - \frac{7n^6}{2^2 4^2 6^2} + \ldots$$

The first five roots and their squares are

$$\left.\begin{aligned} n_1 &= 1{\cdot}256, & n_2 &= 4{\cdot}079, & n_3 &= 7{\cdot}155, & n_4 &= 10{\cdot}271, & n_5 &= 13{\cdot}48, \\ n_1^2 &= 1{\cdot}577, & n_2^2 &= 16{\cdot}637, & n_3^2 &= 51{\cdot}203, & n_4^2 &= 105{\cdot}492, & n_5^2 &= 181{\cdot}71, \end{aligned}\right\}; \quad (90)$$

which may be compared with (75) to see the relative and absolute changes in the values of the time constants.

In the first normal system the magnetic force falls only about 40 per cent. from the axis to the boundary, instead of to zero, whilst it subsides nearly four times as slowly. The amount of shifting of the roots by closing the coil circuit depends mainly upon the time constant of the circuit, which varies with the external resistance. Starting with infinite resistance, the roots are at B_1, B_2, &c., corresponding to $J_0(na)=0$. Reduce the resistance; they move to the left, and of course stop when the coil is short circuited. Now, if we could reduce the coil resistance indefinitely without altering the number of wires, say by increasing the specific conductivity, the roots would be given by $J_1(na)=0$, viz., zero, and the values of na at the other places where the curve J_1 in Fig. 1 crosses the axis of abscissæ.

From this we may, without calculation, derive some interesting information. The first normal system $A_1J_0(n_1r)e^{D_1t}$ becomes, with $n=0$, and consequently $D=0$, simply A_1. If then the initial distribution H_0 was constant, we have $H_0=A_1$, and $A_2=A_3=\ldots=0$. The core's induction does not subside at all, being wholly represented by the first normal function, which has become a constant. But should the initial distribution vary in strength from layer to layer, the value of A_1 will be the *mean* strength taken over the section of the core, whilst the departure from the mean strength will be represented by the other normal systems $A_2J_0(n_2r)$, &c. These, having finite time constants, will subside, leaving the mean strength of force, which will remain steady, with no current in the core, but with a current in the coil of the necessary strength to cause the magnetic force, *i.e.*, as given by $H=4\pi N\Gamma$, N being the number of turns of wire per unit length of core, and Γ the current in each of them. (Of course we should rather say that the magnetic force causes the current, but this is a mere question of words. The essential idea, whichever we like to consider as causing the other, is that the magnetic force and the current are inseparably bound.) This is an illustration of Maxwell's theory of the impermeability of a perfect conductor to magnetic induction. Our core is bounded by a perfectly conducting shell, and whatever magnetic induction was in it cannot get out of it; it can merely settle down to a steady state, in case it was previously non-uniformly distributed.

From this we see that with a core of high magnetic permeability, bounded by a coil of high conductivity short-circuited, any irregularities in the initial distribution of induction will quickly vanish, leaving the mean strength to subside at the slow rate of the first normal system, being during subsidence only a trifle less strong at the boundary than at the axis.

There is another case in which we arrive at precisely the same normal systems given by the roots of $J_1(na)=0$, as when the coil resistance becomes infinitely small, but with entirely different resulting phenomena. For, by continuously increasing the specific resistance of the core we shall make the roots pass continuously from those of $J_0(na)=0$ with $\rho=0$, to those of $J_1(na)=0$, with $\rho=\infty$. The last is of course practicable, as it merely means a nonconducting core. But the relation between D and n being $4\pi\mu D=-n^2\rho$, we have, for all the finite values of n, $D=\infty$, *i.e.*, any irregularities in the initial distribution disappear instantaneously, not gradually as in the last case. But for the value $n_0=0$, with $\rho=\infty$, we have D_0 finite. In fact, the determinantal equation, expressed in terms of D instead of n^2, reduces to

$$0=1+LD/R$$

simply, the coefficients of the higher powers of D vanishing. Hence $D_0=R/L$, and the solution is $H=H_0e^{-Rt/L}$, as we know it should be, there being no possibility of induced currents in a nonconducting core to alter the character of the subsidence. The higher normal systems have become ghosts, and gone to that region where exist all the roots save one of an equation of the first degree.

Returning to the general subject of this section, very little modification of the investigation in Example 1 is needed to complete the solution. For, by (89), $v_1/v'_1=v_2/v'_2=\text{constant}$ for every normal system. Thus the right hand member of (76) still vanishes, giving us the same conjugate property (77) as before, and the same expression (78) for A, whose further development is, however, different. Thus, to find its denominator, use (79), remembering that $r\frac{dv}{dr}=n\frac{dv}{dn}$, and $\frac{dv}{d(n^2)}=\frac{1}{2n}\frac{dv}{dn}$; then,

$$\int v^2rdr=\frac{1}{2n^2}\left[r^2(v')^2-v\frac{d}{dr}(rv')\right]=\frac{1}{2n^2}[r^2(v')^2+n^2r^2v^2],\ \text{by (67)}$$

$$=\tfrac{1}{2}a^2[\{J_0(na)\}^2+\{J_1(na)\}^2],\ \text{by (73)},$$

$$=\tfrac{1}{2}a^2(1+s^2n^2)\{J_1(na)\}^2,\ \text{by (89)} \quad . \quad . \quad . \quad (91)$$

which we see returns to (80), when $R=\infty$, making $s=0$. This completes the solution when the initial H_0 is unstated. But H_0 is to be constant; hence, evaluating the numerator of (78), we have the same expression, $H_0aJ_1(na)/n$, as before, and we obtain, generally,

$$A=2H_0\div\{naJ_1(na)(1+s^2n^2)\} \quad . \quad . \quad . \quad (92)$$

which, in the calculated case, becomes, with $s=1$, and $a=1$,

$$A=2H_0\div\{n(1+n^2)J_1(na)\} \quad . \quad . \quad . \quad . \quad (93)$$

which, taken in the formula

$$H=\Sigma AJ_0(nr)e^{Dt},$$

gives us the complete solution at time t, the current being got by differentiation. The magnetic energy per unit length of core at the start is

$$\tfrac{1}{8}\mu a^2H_0{}^2=T=\Sigma\frac{\mu}{8\pi}\int_0^a 2\pi rdr\{AJ_0(nr)\}^2$$

$$=\tfrac{1}{2}\mu H_0{}^2\Sigma n^{-2}(1+s^2n^2)^{-1} \quad . \quad . \quad . \quad . \quad (94)$$

by (89) and (91), no products being required. At time t the corresponding value of T is got by multiplying each term in the summation by e^{2Dt} with the proper value of D.

With $s=1$, as in the calculated case, the proportions of the initial energy going to the first few normal systems we find to be given by

$$\tfrac{1}{8}=\cdot1230+\cdot0017+\cdot00018+\cdot00003+\ldots$$

Thus, although the second and higher normal systems are very important for a short time from the commencement of subsidence, yet the energy of the first system is no less than $\frac{123}{125}$ of the total. The proportion is not so great when the circuit is open (Example 1) being then only $\frac{88}{125}$ of the whole.

Description of Fig. 3.

This is to show the manner of subsidence of the magnetic force at the axis and at the boundary, and of the coil current in three cases.

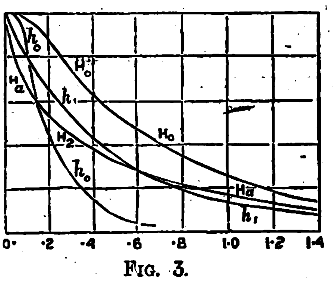

FIG. 3.

Time is measured from left to right, from $t=0$ to $t=1\cdot4$ second, as it happens. Strength of magnetic force (or of current) is measured upwards. The time constant of the coil is $\frac{1}{2}$sec. and its radius 1cm. That is,

$$s=1,\ a=1,\ D=-n^2,\ L/R=\tfrac{1}{2}.$$

As the coil is of very small depth, there must be a great number of turns per cm., or else a soft iron core, to make the time constant so large.

In the first place, suppose that the core is properly divided, to stop the flow of induced currents, and that we start with a steady current in the coil circuit, and, removing the E.M.F., leave it to itself. The curve h_1h_1 shows the manner of its subsidence. It is the ordinary exponential curve, and is given by

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$h_1 = e^{-2t}$, if the value at the start be taken as unity. The characteristic property is that if the current fall from strength 1 to $\frac{1}{2}$ in the time t, it falls from $\frac{1}{2}$ to $\frac{1}{4}$ in the next interval of time t, from $\frac{1}{4}$ to $\frac{1}{8}$ in the third, and so on. The magnetic force, induction, and the magnetisation, if of soft iron, subside in the same manner in all parts of the core on the usual hypothesis of no retentiveness.

Now undo the insulation of the core, so that an induced current can flow as the coil current subsides, other things being the same. The subsidence of the coil current is now shown by the curve H_aH_a. Comparing this with h_1h_1, there is seen to be a general resemblance, with two notable differences: First, and most important, there is a very sudden drop in the strength of the coil current at the commencement, the curve being nearly vertical. This is the first effect of allowing the core current to flow, it being of considerable density, but practically confined to near the boundary. The current is apparently transferred from the coil to the core. But later on, as the core current travels into the core, the coil current subsides less quickly, and finally we have the second difference, a slower subsidence than when the core was divided.

These two effects are characteristic of induction in general between a primary and a secondary, a sudden drop in the strength of the primary, sometimes of very large amount, accompanying the simultaneous appearance of the secondary current in the same direction, and a later more slow subsidence of what is left of the primary current than if the secondary circuit were interrupted.

The same curve H_aH_a shows the manner of subsidence of the magnetic force at the boundary of the core, and of the density of the induced current close to the coil, for they both keep pace with the coil current just outside.

Under the same circumstances the fall in the strength of the magnetic force at the axis of the core is shown by the curve H_0H_0, whose principal characteristics are the preliminary retardation and the opposite curvature of the first portion of the curve from the remainder. Although, according to the formula, the axial force commences to subside instantaneously, yet for a certain time the fall is so excessively small as to be quite insensible. The terms of the series are alternately positive and negative, and, with small values of t, a very large number of them and careful calculation is required to obtain evidence of any fall at all. But, this dead period got over, the rapidity of subsidence increases fast. Ultimately the curve settles down to be the curve of subsidence of the first normal system.

Between H_aH_a and H_0H_0 lie the curves of subsidence of magnetic force at points between the boundary and the axis; as we pass outward from the axis the length of the dead period decreases, and ceases entirely at the boundary.

So far with the coil circuit closed. Now, starting as before, with the steady current and magnetic force, make the resistance of the coil circuit very great (the E.M.F. to be removed). The current in it disappears at once, and the subsidence of the magnetic force in the core is greatly accelerated, the curve being shown by h_0h_0 for points on the axis, corresponding to H_0H_0 with circuit closed.

If we wish to see how the current and force rise to their final strengths when a steady E.M.F. is put in the coil circuit, initially free from current (as also the core), all we have to do is to turn the diagram (Fig. 3) upside down, and view its reflection in a mirror.

Regarding the dead interval, there is this curious property. At the time $t=0$, the rate of decrease of H at the axis is obviously zero. Not only that, but each of the whole series of successive differential coefficients of H with respect to t is then zero, except the ∞th, and that is infinitely great. This statement requires interpretation, of course, because the number of differential coefficients is infinitely great. The interpretation may be got by considering the core to consist of a finite though very great number, m, of concentric cylinders. Then all the differential coefficients $=0$ except the mth, which is very large. Increase m indefinitely, and we approximate as nearly as we please to the solid core, with the above result.

(TO BE CONTINUED.)

HEALTH EXHIBITION.—VII.

One of the largest exhibits is that of the GULCHER ELECTRIC LIGHT COMPANY. This installation comprises 8 "Gulcher" dynamos of the No. 4 type; 59 "Gulcher" arc lamps, and about 500 Crookes incandescent lamps, detailed as follows: Four compound wound dynamos, specially constructed of a new and approved design, having a terminal E.M.F. of 105 volts, supplying the 350 incandescent lamps in the Dairies. The system of winding in these machines admits of any number of the lamps being turned on or off without perceptibly affecting the remainder or causing injury to the machine. Four dynamos, with a terminal E.M.F. of 70 volts, supplying 50 arc lights of 500 actual candle-power in the Eastern Gallery and Chinese Court, and 1 of 2,300 candle-power outside the Entrance; also 138 incandescent lamps, and 8 500 candle-power arcs in the Chinese Restaurant.

Special attention has been paid to the arrangement of the lamps in the Dairies in order to obtain an artistic effect, and in the Chinese Restaurant also the lighting is strictly in keeping with the character of the building, the arc lamps and the outer row of incandescent lamps under the Verandah being enclosed in Chinese lanterns.

In the Eastern Gallery care has been taken to suspend the lamps in a neat and elegant manner, and in the China Court the arc lamps are enclosed in Chinese lanterns, again to be strictly in keeping with the decorations of the building.

All dynamos giving the same E.M.F. are connected parallel, and, in order to equalise the E.M.F. in each, are arranged so that the electro-magnets of any machine are excited by the current generated in one of the others. The coupling-up is effected by means of a novel switch, and is such that one or more machines may be switched off, still keeping the same relative connections between those left working. The system adopted is to have one more machine than is necessary for doing the work, so that in the event of a machine breaking down this spare one is switched on in its place, whilst the damaged one is cut out of circuit.

There is a further advantage in this method, viz., that any one of the machines may become the spare or "stand by," and thus they may be worked alternately so as to secure even wear and tear in working. It may be mentioned here that the still somewhat novel method may be seen in the Chinese section of arc and incandescent lamps upon the same leads.

The armatures of the dynamos are of the Gramme type, and are constructed as follows:—A flat wooden ring is made up of sections glued together to avoid warping. A number of thin flat rings of charcoal sheet-iron are laid upon each side of the wooden ring, a thin sheet of asbestos paper being placed between each contiguous iron ring. The whole is riveted together with soft iron rivets. The ring thus formed is turned and faced accurately, the centre wooden part being left above the iron sides. The wooden rim left standing above the iron is slotted out in 52 equi-distant places for the wire coils to pass through. This serves as a guide for winding, and also effectually prevents any displacement of the coils. The coils are 52 in number, and their lower portion, viz., that part which embraces the inner annulus of the ring forms a V shape, which enables the ring to be firmly clamped by two gun-metal discs, which are provided with flanged edges for that purpose; a washer of leather is placed between the disc flanges and the coils to protect the latter. The wires connecting the armature coils to the commutator are brought through a steel sleeve, which is shrunk on the spindle and forms the bearing surface. This arrangement permits of the use of an overhanging commutator, which is easy to get at and attend to, and at the same time somewhat reduces the length of the machine. Fig. 1 shows a perspective view of one of the Gülcher machines.

The field magnets consist of four poles arranged alternately north and south, thus dividing the armature into four circuits, and thereby reducing its resistance to $\frac{1}{16}$th of the actual resistance of the wire. At the time when Mr. Gülcher first introduced this machine the form of the pole shoe was peculiar, but latterly it has been imitated. The form referred to is an embracing shoe covering the top of the coil as well as the side

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faces, thus making the U-shaped shoe which is now so much adopted.

This shape has been thought by many to be of questionable advantage, but according to recent experiences of the company the gain in efficiency appears to be considerable. In the new pattern machine cast-iron pole shoes have been adopted with cylindrical wrought-iron cores. In this pattern the field magnets are arranged nearer the periphery of the armature, the exact position being such that a circle drawn through the axes of the electro-magnets would divide the side of the armature ring into two concentric rings of equal area. The field magnets are method has the effect of balancing the strength of all, and of bringing them to one mean standard. The above connections are made through a novel "exchange" switch supplied to each machine. These switches are so arranged that any number of machines can be coupled up, and any combination of that number can be used at one time, so that in a very large installation it is only necessary to have one spare machine, which may be switched on at a moment's notice, whilst the bad one is cut out without stopping or affecting the lights. Fig. 2 is a diagram of connections showing three machines on and one machine off. The collector is of phosphor bronze, and is made

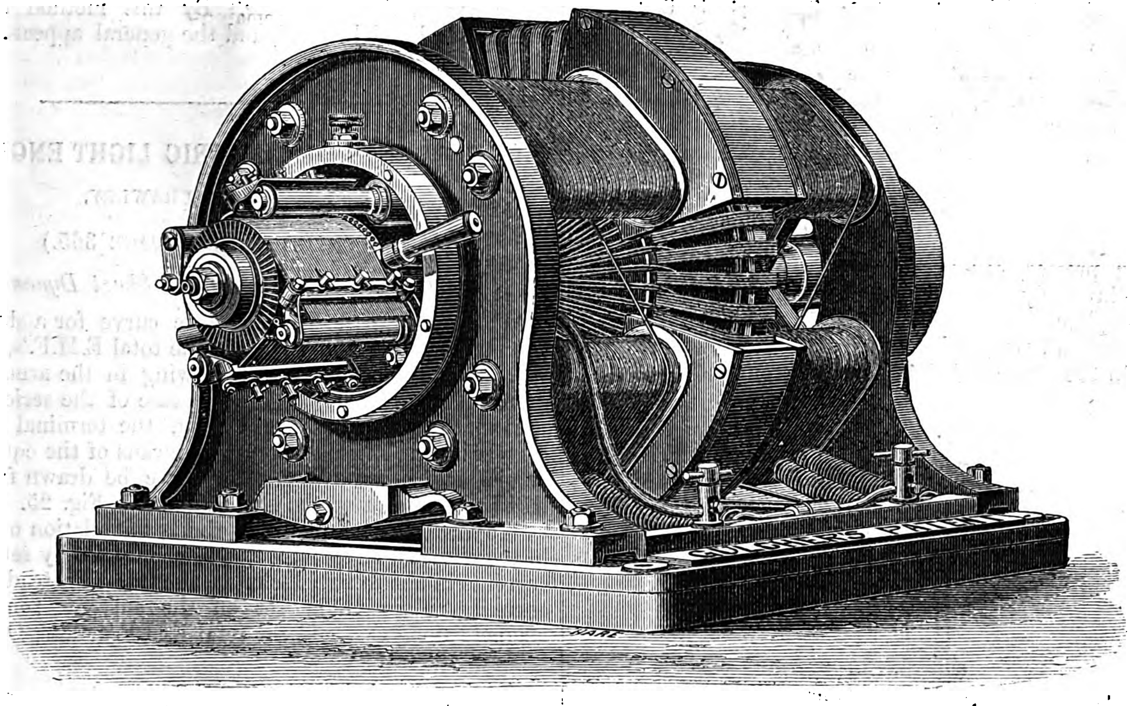

Fig. 1.—The Gülcher Dynamo.

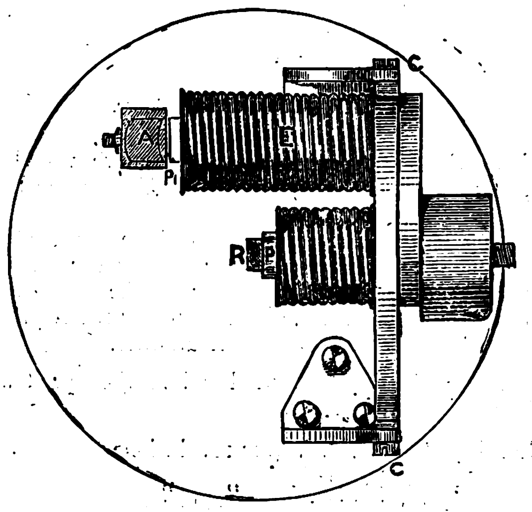

Fig. 3.—Plan—Gülcher Arc Lamp.

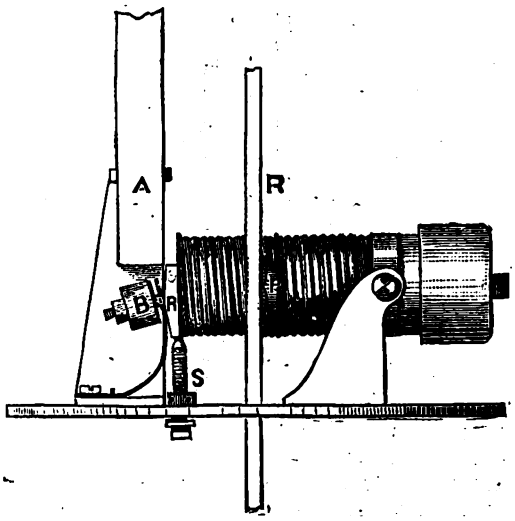

Fig. 4.—Elevation—Gülcher Arc Lamp.

either simple or compound wound as desired, five of those exhibited being compound machines. All the magnet bobbins are connected in multiple arc with each other, the whole being in series with the outer circuit, whilst the shunt wires on the compound bobbins are in series with each other, and the whole connected to the terminals as a shunt to the outer circuit.

All machines intended to give the same E.M.F. are joined in multiple arc, and to secure absolute equality in E.M.F. in each the field magnets are excited in each case by the current generated in the armature of one of the other machines. This in 52 segments insulated from each other by asbestos paper. The spindle is made of cast steel, running in phosphor bronze bearings.

The Gülcher arc lamp regulates entirely by variations in the strength of an electro-magnet, which controls all the actions of the lamp. Referring to the diagram (Fig. 3), E is an electro-magnet of horse-shoe shape, the polar extremity projecting through the short bobbin is sheathed with brass, as will be best seen from (Fig. 4) the elevation, so that when the axis of the magnet is in a horizontal plane, the point, or rather

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line of contact, will be made on the knife edge of iron, but when the magnet attains the position shown in the diagram, *i.e.*, resting on the stud S, the contact is between the soft iron rod R and the brass sheathing; N is a soft iron nut screwed on to a stud projecting from a brass or other non-magnetic spring, and by its attraction to the magnet pole, against which the

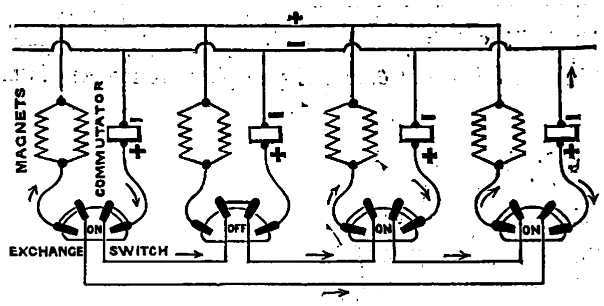

FIG. 2.

brass spring presses, causes friction in proportion to the current, and inversely to the length of the arc. Fig. 5 shows the lamp complete.

The lamps are all arranged parallel, and their action is as follows:—On the current being passed through the electro-

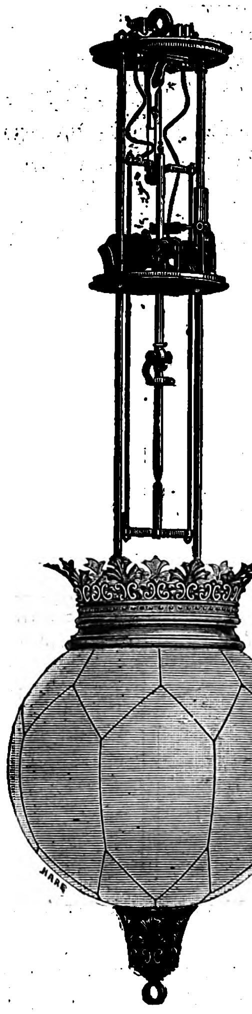

FIG. 5.—Gülcher Arc Lamp.

magnet the long arm is attracted by the fixed armature A, whilst the rod is gripped and lifted by the short end. As the consumption of carbons proceeds the rocking magnet gradually sinks until it attains the position shown in the diagram, the pole piece resting on the stud S. In this position the normal current strength is just sufficient to produce the magnetism required to support the weight of the rod and upper carbon; any increased length of arc and consequent weakening of the current is now followed by a corresponding fall of the rod, and in a well-adjusted lamp there is a practically constant feed in this position. Should the carbons get too close together by an accidental drop, the rocking magnet again lifts as at first. The claims for this lamp are its extreme simplicity and few working parts to get clogged or damaged. A lamp once adjusted is said to be adjusted for all time. The sensitiveness of the magnetic brake enables the lamp to burn most successfully in multiple arc.

The lamps are suspended over pulleys with counterweights by means of the conductor. By this method they can be easily raised and lowered, and the general appearance is neat and elegant.

THE ELEMENTS OF ELECTRIC LIGHT ENGINEERING.

BY C. W. S. CRAWLEY.

(CONTINUED FROM PAGE 365.)

Characteristic Curve for a Shunt Dynamo.

We may draw the characteristic curve for a shunt dynamo by setting off on the axis O Y the total E.M.F.'s, and on O X the total currents (or currents flowing in the armature) which correspond to them, as in the case of the series machine; these values can be found from the terminal E.M.F. and current in the external circuit by means of the equations given before, and if a characteristic curve be drawn from them, it will be somewhat of the shape shown in Fig. 25.

We may also draw a curve giving the relation of the current in the external circuit to the total E.M.F., by setting off the currents in the external circuit along O X instead of the total currents, or we might set off the currents round the field magnets along O X and the total E.M.F.'s along O Y.

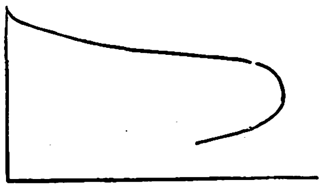

FIG. 25.—Characteristic Curve.

Perhaps the most practically useful curve would be that drawn by setting off the terminal E.M.F.'s along O Y, and the external currents along O X.

In taking observations for any of these curves, the speed should be kept constant if possible; if, however, we cannot do so, we must note the speeds, and employ the following method for finding the total E.M.F. and current for the required speed when the observations are taken at another.

Let n = the required speed and m the speed at which the observations were taken.

Let E_m = total E.M.F. at m revolutions.
C_m = total current " "
E_n = total E.M.F at n revolutions.
C_n = total current " "
e = terminal E.M.F.
A = resistance of armature.

If we maintain the current round the field magnets constant, the total E.M.F. varies as the speed; to maintain this current constant e must remain constant.

Suppose this to be the case, then

$$E_n = E_m \times \frac{n}{m},$$

$$C_n = \frac{E_n - e}{A}, \text{ and } C_m = \frac{E_m - e}{A};$$

therefore $$C_n = C_m \frac{E_n - e}{E_m - e} = C_m \frac{n E_m - m e}{m (E_m - e)}.$$

If we substitute for E_m and C_m their values in terms of the terminal E.M.F. and external current at m revolutions, as obtained in the equation given before, we have

$$E_n = \frac{n\{e(A+B) + A B p\}}{m B}$$

and $$C_n = \frac{e\{n A + B(n-m)\} + n A B p}{m A B}$$

By plotting off C_n along O X and E_n along O Y we can obtain points for the curve at n revolutions.

It may make the above clearer to point out that having found the total C and E corresponding to any terminal E.M.F., e at m revs., we can thence deduce what total C and E will occur at n revs. when the terminal E.M.F. is the same or $= e$. It must be remembered that it is *most* desirable that all points in a curve should be taken at the *same* speed; the methods given for varying speeds being only used when, owing to defective government of the engine, it cannot be kept constant.

Efficiency.

Work in the external circuit or $w = p^2 P$.

Total electrical work or $W = a^2 \left(A + \frac{B P}{B+P}\right)$.

Electrical efficiency or $\frac{w}{W} = \frac{p^2 P}{a^2 \left(A + \frac{B P}{B+P}\right)}$.

Now $$a = \frac{e}{B} + p = \frac{p(B+P)}{B};$$

therefore $$\text{efficiency} = \frac{B^2 P}{(B+P)\{A(B+P) + B P\}}.$$

This equation gives the electrical efficiency of a shunt dynamo in terms of its resistances and that of the external circuit.

Work in electrical horse-power expended in the armature of a shunt dynamo in terms of its internal resistance in ohms, external current in amperes, and terminal E.M.F. in volts

$$= \frac{a^2 A}{746} = \frac{A(e + B p)^2}{746 B^2} \text{ h.p.}$$

That in the field magnets $= \frac{e^2}{746 B}$ h.p.

That in total internal resistance $= \frac{(e + B p)^2 A + e^2 B}{746 B^2}$ h.p.

That in the external circuit $= \frac{e p}{746}$ h.p.

The mechanical efficiency of the shunt dynamo is exactly the same ratio as that of the series, and is therefore measured in the same manner.

Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending 29th August were £2,620, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

West India and Panama Telegraph Company.—The estimated traffic receipts of this company for the half month ended the 31st August are £2,490, as compared with £2,074 in the corresponding period of 1883.

Eastern Extension Telegraph Company.—The traffic receipts of this company for the month of August amounted to £35,967, and to £38,126 in the corresponding period of 1883.

Direct Spanish Telegraph Company.—The estimated traffic receipts of this company for the month of August are £1,173, against £1,547 in the corresponding period of last year.

Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ending the 22nd inst. amounted to £3,219.

ON HALL'S PHENOMENON IN LIQUIDS.

According to M. Anton Roiti, Hall has shown that when a current is passed through a thin plate of metal, there is a transverse E.M.F. induced in the plate, if it is placed with its plane perpendicular to the lines of force of a magnetic field. This is the phenomenon suggested as possible by Maxwell, and expressed by the assumption of a "rotatory coefficient" in the equations of conduction. Hall has determined this coefficient for various metals. The author first experimented with a sheet of silver electrolytically deposited on glass, and in general verified Hall's results. The experiment was then tried in a different way. The main current was passed through a silver wire, A B, 0·03 millimetre in diameter, and about 4 centimetres long, held by two stout copper wires. At right angles to this was a second similar silver wire, C D, forming a cross with the first. This second wire was stretched by two suspended weights, and had stout copper wires similarly attached to it. The plane of the wires was at right angles to the lines of magnetic force, their point of intersection being in the axis of the electro-magnets. The copper terminals of C D were connected with an exceedingly sensitive galvanometer. It was found that if the tension of the wire was considerable, no effect whatever could be observed when the direction of the field was reversed, even with a primary current produced by six Daniell's. This shows that the supposition of a direct effect upon the current is not admissible, and that the phenomenon really depends upon a change in the specific resistance, in the manner considered by Maxwell. In experimenting on liquids, the author found that the polarisation introduced considerable difficulties, but he concludes from experiments with sulphate of zinc solution, that if the concentration of the solution is less than that of maximum electrical conductivity (specific gravity 1·286), the electro-dynamic action produces an increase in the conductivity of the liquid in the direction of C D, and conversely if the concentration is greater than that of maximum conductivity.—Institute of Civil Engineers' *Transactions.*

ON THE ELECTROLYSIS OF SOLID GLASS.

The facts described in the paper of M. E. Warburg in *Wiedmann's Annalen*, says the *Phil. Mag.*, may be summarised in the following manner:—

In the electrolysis of lime-soda glass heated to about 300 degrees between mercury electrodes, a badly conducting layer of silicic acid is formed on the anode side of the glass, which soon reduces the strength of the current to a fraction of its original value. This layer has a greater or less thickness, according as a greater or lesser electromotive force has acted in the circuit in a definite time. It is visible, showing the colours of thin plates, diminishes the surface-conductivity of the glass in the cold to a fraction of its original amount, and at a high temperature, when the mass of the glass has become a conductor, it acts like the dielectric of a condenser whose coatings are the conducting mass of the glass, and the mercury of the anode. The capacity of this condenser was found to be independent of the difference of potentials of the coatings, between 1 and 20 Bunsen elements; and for a square centimetre of the glass used it varied from 0·021 to 0·041 microfarad, according as the layer was formed by 30 or 15 Bunsen elements acting for several hours at 300deg. The formation of this layer may be avoided by using sodium amalgam as anode; the result of the electrolysis may then be quantitatively determined. In this a quantity of sodium is given off at the cathode and absorbed at the anode, so that the weight of the glass does not vary; the weight of the sodium is chemically equivalent to the weight of the silver which is deposited at the same time in the silver voltameter. During electrolysis the glass remains perfectly clear, and it was found that all the properties of the glass were not appreciably altered by electrolysis.

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CONTENTS.

Notes	381	The British Association	392
The Induction of Currents in Cores. By Oliver Heaviside. (Continued.) Illustrated	386	Correspondence	393 and 394
The Health Exhibition.—VII. Illustrated	388	On Normal Elements for Electrometric Measurements. By W. H. Beetz	394
The Elements of Electric Light Engineering. By C. W. S. Crawley. (Continued.) Illus.	390	Electric Lighting in Brussels	396
On Hall's Phenomenon in Liquids	391	Trees and Lightning	397
On the Electrolysis of Solid Glass	391	The British Association at Montreal. Illustrated	397
		Telephony in South Australia	402
		Telegraph Traffic Receipts for August, 1884	403
		Companies' Share List	404

IMPORTANT NOTICE.

*** All communications should be sent to our new offices, 1, Salisbury-court, Fleet-street, E.C., where *The Electrician* is now printed and published.

THE BRITISH ASSOCIATION.

The members and Council of the British Association are this year to be congratulated not only on the fortunate occasion which has carried them to the hospitable and romantic shores of their fellow countrymen in the far West, but in the choice of a president who combines in his own person qualities most highly esteemed by their generous hosts. From the circumstance of his birth, his political associations, as well as his devotion to those objects which the Association is engaged in promoting, Lord Rayleigh is a typical English gentleman whom we are proud to have as our representative at Montreal just now. But in other respects also he has exceptional qualifications for presiding over a gathering which, held in a strange land, must needs be as comprehensive in its character as possible. Lord Rayleigh is a professed physicist; and, to use his own words, the subjects included under the head of physics are so numerous that no one man can do justice to them all; but no living scientist probably would have done them less injustice than this year's President of the British Association.

The presidential address usually provokes some attention at the hands of the English newspapers, and not always of the appreciative sort; but we do not remember any in recent years that has given rise to such lengthened and at the same time such friendly comment as the one just delivered at Montreal. This is to be ascribed partly, no doubt, to the unaggressive tone of the address, a characteristic to which we shall refer again presently; but more particularly to the generally attractive and instructive facts which he has succeeded in bringing together in an intelligible form. Hardly any branch of physics escaped his observation, from Electricity to Spectroscopy, and from Dynamics to Acoustics; and the extent of its reproduction in the public press is testimony to his treatment of these subjects, besides being evidence of a growing and intelligent interest in their study outside the strict boundaries of the scientific world. Electricity, of course, came in for the lion's share of attention; and we note with satisfaction Lord Rayleigh's remarks on the subject of absolute standards of measurement for electromotive force, current, and resistance. As regards resistance, the agreement arrived at by the Conference of Electricians differs only a little more than 1 per cent. from that arrived at twenty years ago by the British Association. A more decided recommendation is given to Mr. Latimer Clark's permanent form of standard cell, whose electromotive force is determined almost once for all. To complete the scheme of electrical measurement Lord Rayleigh recommends the application of Faraday's electrolytic law. The results recently obtained by himself and Professor Kohlrausch, namely, that one ampere flowing for one hour decomposes 4·025 grains of silver, are in such close agreement that they can hardly be in error by more than a thousandth part. This number being known, the silver voltameter gives a ready and accurate method of measuring currents of intensity varying from 1·10 ampere to four or five amperes. With reference to this study of electrolysis, Lord Rayleigh ventured the prediction that we may expect the next great advance in scientific knowledge will come from that direction, with improved views as to the nature of chemical reactions and of the forces concerned in bringing them about.

While sharing the common regret that the application of electricity to the purposes of power and illumination had been somewhat discredited by ignorant and speculating promoters, Lord Rayleigh added words of encouragement, based on scientific knowledge. Assured on sound theoretical grounds that we are on the right track, he recommends us to push the attack persistently when we can be sure, as in this case, that the obstacles to be overcome are only those of contrivance, and that we are not vainly fighting unawares against a law of nature. Referring to the new interest in the study of acoustics awakened by the discoveries of Graham Bell and Hughes, and to the failure of attempts to explain their action, Lord Rayleigh points out that molecular changes in solid masses are inaudible in themselves, and only capable of reaching the ear when their external surface is set in motion; and that if the surface of a solid remains undisturbed our ears can tell us nothing of what goes on in the interior, facts which we should do well to remember in pursuing the investigation of telephonic and microphonic phenomena.

With Lord Rayleigh's concluding observations on the relative value of scientific and literary education there has been a general agreement of public opinion, from which we are in no

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way disposed to dissent. As against the study of the dead languages his lordship thinks that a scientific training might be preferable; and at all events quite as serviceable in the forming the mind into habits of accurate thought. But when there exists no taste or aptitude for scientific ideas a study of modern languages would be eminently more practical than that of either science or the classics. In any case he doubts whether an exclusively scientific training would prove satisfactory; and so do we, for to a vast number of minds it would be as barren of results—except as mental training for which either will serve indifferently—as is usually the time spent on a classical education. By results, of course, we mean visible results; but there are many indirect advantages from the early study of literature, and its advocates justly esteem them more highly than any likely to be derived from time exclusively devoted to science in early youth. For ourselves we think that such an education would be narrow in almost its worst sense, and would give us, wherever it succeeded, a plentiful crop of prigs. Lord Rayleigh, with gentle derision, calls them "prophets"—self-elected prophets—whose opinions in reality on the general affairs of this life, and especially concerning the higher mysteries of our being, are worth not a bit more than those of other intellectual men educated in the ordinary way. But leaving these points of disputation, no one will deny Lord Rayleigh's claim for science, that it is always progressive, whilst in other departments of human life progress is rather an article of faith than a rational belief. We cannot be sure of our progression in political or social affairs; we know, on the other hand, that increasing knowledge brings increasing power, and a foretaste of fresh triumphs in store for us. This is the message which the British Association has carried to the New World; and we share in the hope that "a larger measure of the youthful activity of the West will be drawn into its service."

CORRESPONDENCE.

ANOTHER SOLUTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The question often arises in the inquiring mind—What is electricity? I have read many so-called explanations of the phenomena, notably Mr. Sprague's and Clerk-Maxwell's, besides several others, but none of them seem to correspond with the manifestations of the phenomenon so entirely as a certain theory of my own which I formed many years ago from a number of different experiments. I have often thought I should like to make my theory public, but as nobody seems to see it in the same way, I have held back, and only just among a few private friends have I mentioned the matter. I will put it as I condensed it in my note-book. Electricity is a decomposition of the negative and positive atoms composing the molecules of ether. I will explain what I mean by the word "ether." Ether is a semi-material imponderable (the word "substance" will not do), I will say "something," corresponding in idea to a very attenuated gas without its material attributes, that fills all space that is not occupied by matter; that every atom of matter is surrounded by a molecule of ether; that the composition of a molecule of ether varies as to its negative and positive atoms according to the matter it is associated with; that the decomposition and (for chemical different) reforming of the molecule of ether causes both chemical and electrical phenomena; that ether attracts matter and matter attracts ether; that energy is different motions of the ether, such as expansion and contraction, decomposition and recomposition of the molecules of ether. Ether is capable of indefinite expansion and contraction. Heat expands the molecules, or to speak more correctly, heat *is* the expansion of the molecules of ether, *i.e.*, if the molecules of ether expand, that constitutes the sensation of heat to us, and likewise the phenomenon of motion through the resistance of the mutual attraction of ether and matter. But I am digressing. The question is, What is electricity? From my experimenting I theorise thus: That every conductor of electricity is composed of molecules; that round every atom composing these molecules is a molecule of ether composed of (in varying relative quantities) negative and positive atoms, and when these molecules are broken or decomposed (say by a primary circuit on a Ruhmkorff) a current of electricity is the result. The negative flowing (and by a series of decompositions) in one direction and one side of the wire round the completed circuit, and the positive atom in the reverse. Electromotive force is the force or violence with which the atoms are separated irrespective of the number of lines of force which are started. Strength of current (old quantity) is the number of lines started and completed in the circuit. I have only room to mention the experiment that convinced me that magnetism and electricity were etheral phenomena. I placed a small compass needle inside a small glass globe; something similar to what they afterwards used for incandescent lamps, and by the aid of a Sprengal I exhausted the air, and hermetically sealed it. I took another globe and needle without the exhaustion and sealing. The two needles were deflected exactly alike by a permanent magnet on the outside. Nothing could account for this but the intervention of ether. Depend upon it they may beat about the bush as long as they like. Ether alone gives a rational clearing up of the mystery. I should have liked to have given a few other ideas of mine connected therewith, but I think I have inflicted enough for once, so I will forbear.—Yours, &c.,

W. ALDRED.

5, Brightside-bank, Brightside, Sheffield.

THE PILSEN JOEL ELECTRIC LIGHT COMPANY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice an error in your report of my remarks made at the Pilsen Joel and General Electric Light Company (Limited), at the general meeting, held last Thursday, the 27th August. From your report it would appear that I had spoken of the Anglo-American Brush Company as having the best lamp in the market, &c., whereas I stated that it was the Pilsen Company whose lamp (the Pilsen arc lamp) was the best, and who had started better than any other company, and who ought, therefore, to have done better than any other company.

Will you kindly insert this letter in your next number?—Yours, &c., HENRY F. JOEL.

Tower-chambers, Moorgate-street, London, E.C.,
Sept. 2, 1884.

FITZGERALD'S METHOD FOR MEASURING THE INTERNAL RESISTANCE OF BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to your remark in the review of my "Handbook of Electrical Testing," which appeared in your issue of the 23rd August, "we might suggest the addition of . . . FitzGerald's method for measuring the internal resistance of batteries," I would point out that this method has been given in each of the three editions of my book (page 35, 1st edition; page 98, para. 110, 3rd Edition). I may also remark that the method is given in detail on page 314 of Sabine's "The Electric Telegraph," published in 1867.—Yours, &c.,

H. B. KEMPE.

General Post Office, Sept. 1.

[The reply of Mr. Kempe is to a certain extent what might be expected; it ought, however, in my estimation, to have been altogether different in tone and matter. Mr. Kempe does not mention FitzGerald's name at all on page 98, para. 110.

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Nor is the name to be found in the preface. Mr. Kempe will probably say that Sabine gives the method without acknowledging the author, and that his text is founded upon Sabine's; or perhaps he may say that the method is not FitzGerald's. I know that Mr. FitzGerald claims the method, and I did not imagine that his claim would be disputed. It is evident also that Mr. Kempe understands this claim; hence I should like to know *why* he fails to name FitzGerald in connection with the method. Throughout the work the desire is so evident to give credit that the exception is singular. My impression is that the method was known as FitzGerald's long before Sabine's book was published, but as I cannot verify the impression for the moment, I mention it for what it is worth. I do not care to argue whether Mr. FitzGerald would accept para. 110 as a good description of his method, and am willing to agree that Mr. Kempe thinks it is, and differs as to its value with Mr. Sprague.—THE WRITER OF THE NOTICE.]

TELEPHONING EXTRAORDINARY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have seen your article in *The Electrician* of August 30th on "Telephoning Extraordinary." The same is, I fear, very liable to create a wrong impression. The writer is entirely familiar with the line used, having on several occasions during the past winter experimented over the same distances mentioned in the article.

1st. The distances given between Bologoie and Petersburg are more than *ten times* too great, the distance being about 370 kilometres (*see* Badeker's *Russia*). 2nd. The distance over which they hope to talk (Petersburg to Moscow) suffers the same stretching.

Considering these figures it will be seen that there is nothing at all "extraordinary" in the matter. Telephoning has been done in America and elsewhere over very much longer distances and under circumstances much more unfavourable.

The line experimented upon is remarkably well situated for telephonic work. From St. Petersburg it runs, it is true, upon the same poles with a few telegraph wires, but only for a distance of five or six miles. From there it runs as an entirely distinct line upon separate poles, and removed two or three hundred feet from all other lines. Being, then, as will be seen, most favourably situated, being moreover exceedingly well insulated, is there anything "extraordinary" that talking could be carried on at night when these other wires (three hundred feet distant) were not in use? At the time the writer heard experiments with the Bell-Blake combination, conversation, but very limited, was imagined to be carried on, but no one claimed anything like success for the experiment.

Russia is a great country, and little developed in its resources, but I am one who believes that our English and American electricians understand how much can be got out of the Bell-Blake combination as well as our Russian neighbours.—Yours, &c., VERIPHONE.

[We have referred to the *Bulletin*, and find the figures therein are as we gave them in our note. As our correspondent points out, there is nothing extraordinary in the experiment when the figures are corrected and the conditions stated.—ED. *E.*].

THE PASSAGE OF A CURRENT THROUGH A CONDUCTOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: How can the passage of a positive and a negative current through a conductor in opposite directions be explained?

My idea of the subject is this—If you have a *positive current* (if it is possible to imagine one) flowing through a wire or other conductor, it produces a certain effect. Now, suppose that you have *negative current* (the same remark applies here as in the former case) flowing through the same conductor in the *same direction*, an effect is produced *opposite* to the former one.

Therefore if the two currents flowed in the *same direction* in a conductor they would *neutralise each other*; the one, as we have seen above, doing exactly the opposite of the other, but if they pass in *opposite directions* (as they do), they co-operate to produce the *same effect*. Still, however, I meet with the objection that it is almost impossible to imagine two currents flowing through the same conductor at the same time in opposite directions.

Be that as it may, I must let those who cannot "stretch" their imagination keep the same ground. I think, however, that the above reasoning will remove the difficulty which arises from thinking that the positive and negative currents in the same direction produce the same results instead of their being totally opposed to each other. I should like to know if this theory is correct, and whether it has been ventilated before.—Yours, &c., A. T. B.

ON NORMAL ELEMENTS FOR ELECTROMETRIC MEASUREMENTS.*

BY W. H. BEETZ.

In order to measure a difference of potential in absolute units a normal element is required, having a perfectly definite electromotive force, which can either be put together once for all, or can always be set up in exactly the same way and without too much trouble. According to Kittler's experiments†, a Daniell element, having a porous cell, does not at all fulfil these conditions, since its electromotive force is subject to continuous change. On the other hand, an element composed of chemically pure zinc and pure copper, in dilute sulphuric acid and copper-sulphate solution of definite strength, the solutions being placed in connection by means of a siphon-tube terminating in small openings and filled with the same sulphuric acid, has always the same electromotive force, and since it can easily be put together, forms a convenient standard cell. Using concentrated copper-sulphate solution and dilute sulphuric acid of specific gravity 1·075, Kittler found the electromotive force of such an element to be 1·195 volt, which decreased to 1·059 volt when the dilute sulphuric acid was replaced by concentrated zinc-sulphate solution.

Of the Daniell elements hitherto employed for measurement of difference of potential, that of Raoult‡ best fulfils the conditions here laid down; that of Lodge§, employing dilute zinc-sulphate solution, less satisfactorily; whilst combinations containing porous cells, such as that proposed by Buff‖, are still less suited to serve as normal elements.

But none of these are able to maintain a constant electromotive force, as is now desirable for electrometric measurements, since in all gradual diffusion of the liquids takes place. I myself¶ have formerly made use of similarly arranged normal elements for measurements made according to the compensation-method; but they do not answer for electrometric measurements, and I have therefore been obliged continually to renew the element. For the length of time during which unbroken observation with the electrometer is usual, we may rely upon the constancy of the element.

The frequent putting together and taking apart of an element is a labour always willingly avoided. Hence the permanently-connected zinc and mercury element of Latimer Clark** was gladly welcomed. Its electromotive force (1·457 volt) was found nearly constant in different preparations of

* Translated in *Phil. Mag.* for September from Wiedemann's *Annalen*, XXII., p. 462.

† *Sitzungsber. d. k. bayer. Akad. d. Wiss.* p. 467 (1882); Wied. *Ann.* XVII., p. 865 (1882).

‡ *Ann. de Chim. et de Phys.* [4] II., p. 345 (1864).

§ *Phil. Mag.* [5], V., p. 1 (1878). ‖ Lieb. *Ann.* LXXXV., p. 4 (1853).

¶ Wied. *Ann.*, IV., p. 5 (1878).

** *Proc.* Roy. Soc., XX., p. 444 (1878); *Beibl.*, II., p. 565 (1878).

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the element according to the method described. But it has two undesirable properties: the one is the great variation of electromotive force with change of temperature, which, however, is easily allowed for in calculation, but which does not exist* in the case of the Daniell elements; the other is the great decrease which the electromotive force suffers if the circuit is closed even for a very short time. This may easily occur. An unintentional contact in some of the auxiliary apparatus employed in the measurements, for example in the key which I have described†, is sufficient to render the element useless for one or several days. I obtained a diminution of electromotive force, amounting to 2 per cent., in a Latimer-Clark element in which the circuit had been closed for only half a minute. A Daniell element would have shown scarcely any change under similar conditions.

But this defect of the Latimer-Clark element may be almost entirely remedied by giving to the cell so great a resistance that only an insignificant current can be generated.

A U-tube of 1 centim. diameter and legs 75 centim. long was filled with the paste of mercury-sulphate and zinc-sulphate solution, prepared according to the instructions, but heated so much that after cooling it became hard. The paste was boiled in the tube by means of a water air-pump. The zinc pole was introduced into the upper end of the tube and the mercury pole into the lower, and the openings were closed with paraffin. The element is very convenient for use on the laboratory table, since the two poles may pass through holes bored in the table, the whole body of the tube being protected underneath the table. The internal resistance of the element was 15,700 ohms‡. Its electromotive force was somewhat smaller than given by Latimer Clark. If, in fact, the electromotive force of a normal Daniell cell (with dilute sulphuric acid) be taken as 1·195 volt, then that of my mercury element was 1·442 volt (instead of 1·457 volt). When the element was short circuited, its electromotive force was as follows:—

After 5 minutes	1·440 volt.
„ 1 hour	1·439 „
„ 4 hours	1·439 „
„ 6 „	1·437 „
„ 12 „	1·434 „
„ 48 „	1·408 „

We see therefore that the element resists the influence of polarisation for a long time. Polarisation could indeed only be very slight, since the current which passed through the element has only the intensity of 0·000091 ampere. The electromotive force only diminished 2 per cent. after use for 48 hours, a decrease which is very small indeed compared with the falling off in the usual form of the Latimer-Clark element. It is easy to avoid short-circuiting the element for such a length of time; but if the element has once become enfeebled, it recovers itself only slowly. Thus, after 24 hours I found its strength to be 1·430 volt.

The idea of replacing the fluid of an element by a solid body may be carried out also with a Daniell element. Fine alabaster plaster of Paris was mixed with concentrated copper-sulphate solution to about the consistency employed in making plaster casts, and some more with concentrated zinc-sulphate solution. A U-shaped glass tube, of 4 millim. diameter and with legs 22 centim. long, was partly filled with the one paste, and after it had set was filled up with the other, so that the two were in close contact. A copper wire was introduced into the copper paste before it had set, and a zinc wire into the zinc paste. The upper part of each leg was cleared from plaster and filled up with paraffin.

Several dry Daniell elements thus prepared were compared with an element put together with concentrated solutions of copper sulphate and zinc sulphate, and tested in respect of the effect of change of temperature, and of short-circuiting. Taking the electromotive force of the liquid element as equal to unity, the three dry elements I., II., and III. gave, when measured on different days:—

	I.	II.	III.
	0·996	0·993	1·000
	0·998	0·996	0·996
	1·000	0·999	0·993
	—	0·998	0·998
Mean...	0·998	0·996	0·997

The temperature varied in all these observations by a few degrees only; the small apparent variations in the electromotive force of the dry elements are partly at least accounted for by small changes in the electromotive force of the fluid element, which was put together fresh each time. On the whole, however, the dry element is a little weaker than the fluid element; it contains no amalgamated zinc, because such amalgamated wires are very brittle.

A second series of experiments was concerned with the influence of temperature. The elements II. and III. sometimes at the temperature of the air, sometimes in baths of different temperatures, were compared with the fluid element, which had always a temperature of nearly 20°C. On account of the small conducting power of the dry elements for heat, they remained always three-quarters of an hour in the bath before the measurements were made. If the electromotive force of the fluid element is again taken as unity, that of the dry element was as follows:—

II.		III.	
At 0°	0·996	At 1°	1·007
„ 20	0·993	„ 21	1·000
„ 39	0·983	„ 32	0·995
		„ 55	0·981

The decrease in electromotive force of each of the two elements for low temperatures between 0° and 20° amounted to only 0·015 per cent. for an increase in temperature of 1°. But the temperature-coefficient increases with increase of temperature. With element II. it amounted to 0·053 between 20° and 30°; with element III. to 0·045 between 21° and 32°, and between 32° and 55° even to 0·061. For Latimer-Clark's element, Helmholtz and von Kittler* agree in finding it to be 0·08. Within the narrow limits within which electrometric measurements are commonly made, the influence of temperature upon the electromotive force of the dry Daniell element may be altogether neglected.

The effect of short-circuiting is seen from the following experiments made with elements I., II., III.

The element was short-circuited for a certain length of time, then contact was broken, and the difference of potential measured. We do not thus obtain actually the lowest value which the difference of potential may attain, since this increases even during the few seconds which the measurement requires; but we do obtain the value with which we are actually concerned in our measurements.

The elements I. and II. were scarcely influenced at all by having the circuit closed for half a minute; but element II. sank from 1·000 to 0·997, but quickly recovered itself completely. The following changes were caused by more prolonged closing of the circuit:—

I.		II.	
	0·998		1·000
After 10 minutes	0·991	After 1 hour	0·994
„ 35 „	0·988	„ 15 hours	0·988
„ 14½ hours	0·975	„ 20 „	0·988
	0·996		0·993
„ 15 „	0·986	„ 15½ „	0·987
5 minutes open	0·994	„ 24 „	0·986
		„ 39 „	0·987
		5 minutes open	0·994

* Kittler, *loc. cit.*, p. 371. † Wied. *Ann.*, X., p. 371 (1880).

‡ The resistances were measured by my first assistant, Dr. Pfeiffer, by the use of alternate currents.

* Kittler, *Sitzungsb.* loc. cit. p. 501.

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III.

	1·000
After 15 minutes	0·996
„ 50 „	0·994
„ 17 hours	0·989
5 minutes open	0·992

After the lapse of a quarter of an hour the open element had in all cases recovered its former electromotive force.

The dry Daniell elements have therefore this in common with Latimer-Clark's element, that they can be prepared once for all; but they have further this advantage, that they are scarcely at all influenced by temperature; and that an accidental closing of the circuit produces only an insignificant decrease even in elements of small size (about 1 per cent.), which is very soon recovered. If the electromotive force of a Daniell element put together with copper, zinc, concentrated copper-sulphate solution, and concentrated zinc-sulphate solution be taken as 1·059 volt, then the mean electromotive force of a dry Daniell element = 1·056. It must, however, be remembered that the value 1·059 is based upon the assumption that the force of a Latimer-Clark element = 1·457 volt, which estimate is only to be considered as a preliminary one.

The resistance of element I. was 14,600 ohms, of element II. 13,500 ohms. The strength of current passing through a short-circuited element is therefore 0·000072 ampere for element II., and 0·000078 ampere for element III.; *i.e.*, in the first 0·08 milligrm. copper would be deposited in the hour, and with the latter 0·09 millgrm. copper.

The dry Daniell elements are to be recommended for another purpose, viz., for charging a quadrant-galvanometer. Zamboni's pile has not proved successful for this purpose; it acts excellently for a time, but then the potential difference of its poles changes suddenly, especially with irregular changes of temperature. Apparently the deposition of moisture on the inside of the glass tube containing the pile produces a partial short-circuiting of the pile. With a water-battery these sudden changes do not occur, but the difference of potentials decreases gradually, if slowly. Errors in measurement cannot be caused thus; but the deflections of the electrometer become smaller and smaller, and, apart from the necessity of renewing the evaporated water from time to time, the whole battery every now and then has to be disconnected and cleaned from deposits of oxide and carbonate. I found the electromotive force of a newly prepared zinc and copper element filled with spring water to be 0·992 volt. After twelve hours, during which the element remained open, it had sunk to 0·934 volt. Three of the elements forming my water battery, which has stood now more than a year, were examined. They showed the following differences of potential:—

0·838 0·678 0·724 volt. ...... Mean 0·743 volt.

The dry Daniell elements may conveniently be combined into a battery which requires no filling, and upon which temperature and moisture are without influence.

Since the resistance of the elements is a matter of indifference, they may be made very small. I have filled glass tubes, 8 centim. long and 5 millim. diameter, half with the copper-sulphate plaster and half with the zinc-sulphate plaster, wires of copper and zinc being placed in the corresponding mixture, which wires were then soldered together. The ends of the tubes are closed with paraffin.

Twelve such elements form a row. Twelve such rows stand one behind the other, each connected with the preceding one by insulated binding-screws, so that each chain of twelve elements hangs between two binding-screws. Any desired number of such series of twelve elements may therefore be taken to produce the charge. The whole battery of 144 elements shows a polar difference of potential of 152 volts; whereas the same difference requires 156 elements of the freshly prepared water-battery and 200 of the enfeebled one. The whole dry battery covers a surface of 16 centimetres square.

Postscript.—In the elements last prepared the zinc wires are amalgamated at the ends and covered elsewhere with shellac, and the concentrated solutions have been diluted with one third of water.

ELECTRIC LIGHTING IN BRUSSELS.

The Grand Place,* Brussels, will shortly be illuminated by the electric light, the temporary installation being all but complete. It comprises the dynamos, &c., established in one of the cellars of the Maison du Roi, intended to supply two large lamps, mounted on masts 20 metres (65ft.) high, each lamp being supplied by its own machine. The two generators are on the Gramme system with flat magnets, greatly resembling the five-light type, from which they only differ in the dimensions and the coil wires. While the five-light machine is intended to generate electricty of high E.M.F. at 1,400 revolutions a minute (these machines give out a current of 13 amperes at 350 volts) the generators put down in the Maison du Roi rather produce electricity in quantity (at one normal speed of 750 revolutions they afford a current of 50 amperes and 65 volts).

This type of machine is used with advantage with incandescent light, in which case they run at 1,100 revolutions, and are capable of maintaining 75 Edison lamps of the **A** or 16-candle type.

The two dynamos are driven by a 12 horse-power Otto gas-engine, making 140 revolutions per minute. It is proposed eventually to modify this motor by providing it with driving pulleys fixed with spiral springs in such a way as to compensate for the irregularities of working, which are not very manifest with arc lighting, but should nevertheless be avoided. It is on this engine that the first and favourable trial was made of an English appliance, the "anti-fluctuator," the object of which is to completely neutralise the influence of the gas engine on gas burners fed from the same pipe.

This lighting of the Grand Place by the Communal Administration of Brussels is not undertaken so much to test the lamps and engines as to give an idea of the effect produced, and on this trial, more or less imperfect, will depend the ultimate decision as to the number and situation of the lamps. A commencement is made with two lamps of 1,000 carcels (say 10,000 candles) each, placed 20 metres (65ft.) high. The later type of Jaspar lamp is used, in which the mechanism for bringing the carbons together is placed above the luminous point. The carbons used are 25 millimetres, or 1in., in diameter; and the construction of the lamp ensures illumination during 7½ hours. The average height of the houses in the Grand Place is 20 metres (65ft.), the cornice of the Maison du Roi being 19 metres (62ft.) above the ground line, and that of the Hôtel de Ville 22 metres (72ft.), so that all the *façades* are illuminated. Moreover, a small slit in each reflector will permit of throwing a pencil of rays over the spire of the Hôtel de Ville, which will therefore be lighted up on three sides. The temporary masts at present erected turn on a pivot at the base for lowering; but the permanent supports will be like the Venetian masts, with large and ornamented bases, which produce so fine an effect in the Piazza San Marco, Venice. The electric current is led from the Maison du Roi to each of the masts by underground conductors, consisting of a single copper wire 5 millimetres (⅕in.) in diameter (about 20 square millimetres sectional area), covered with an insulating substance, then a lead casing, and over that an asphalte coating. The leads which conduct the electricity to the lamps consist of fourteen copper wires of

* Where are situated the fine old Gothic Hôtel de Ville and the ancient houses of the various trade corporations.

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1½ millimetre diameter; they are laid in a groove made in the masts.

If the lighting should be continued permanently it is intended to double the generating power, and appropriate the new machines to illuminating the Hotel de Ville with incandescent lamps. The installation has been made by the Compagnie Générale d'Electricité, under the direction of M. Wybauw, the city engineer.—*Bulletin de la Société Belge d'Electriciens.*

TREES AND LIGHTNING.

Mr. Francis George Heath writes in the *Daily News* from Underwood, Kew Gardens, under date August 21st:—

"I doubt whether even the cholera intelligence (seeing that the scourge is at present abroad) of to-day's paper will have so much attraction for your readers generally as the able and interesting article you publish on thunderstorms and the dangers of lightning. The great human interest in these atmospheric fireworks centres around the curious attraction which the animal body has for lightning; and I was therefore surprised to read of the remarkable suggestion which you quote of the Swiss electrician, that metal rods should be fastened to the trunks of trees at their bases to divert the lightning from the killing of human beings who might be taking shelter under them, for it is well known that the fluids of an animal body are much better conductors of the electric fluid than any metals. A very striking illustration of this fact was given in the death of Mr. Crosse, the famous electrician, who lived near Taunton. Mr. Crosse had a gigantic electrical apparatus and an enormous Leyden jar set up in his house, and he was wont to tap the clouds by means of long conductors. One day, during a terrific thunderstorm which was passing over his house, he became so deeply absorbed in the great sparks which were going 'click, click,' into the metal knob of his jar, that he approached a little too close to it. Instantly a flash entered his forehead, ran through his body, and burst out through the non-conducting leather of his boot, not only killing him immediately, but hurling his body across the room. We must therefore be content, I think, to trust for the protection of foolish people who might wish to resort to trees for shelter in thunderstorms to the oft-repeated warnings on this subject. But the protection of dwellings is another and very important phase of this subject, for the destruction of a dwelling house may mean the destruction of the whole of its occupants, and if we can make the dwelling safe, then we establish at once an important asylum. At the worst, people in the open country can make themselves perfectly safe by lying flat on the ground well away from any prominent perpendicular conductor, such as metal or wood. Respecting the protection of dwellings, then, I should like to make widely known a suggestion for their protection of an altogether pleasant and inexpensive kind. It is the fact that poplars in general, and especially Lombardy poplars, have been proved to be the best tree conductors of electricity. Lombardy poplars are the best, because with the poplar affinity for lightning, they have tall, pointed, narrow forms and a remarkable uprightness of growth, together with an abundance of small but closely set spray. So soon as the tree has risen beyond the woodwork of the roof, if kept, say not less than twelve feet from the wall of the building, a most perfect conductor will have been established; and if several Lombardy poplars are planted around a house, but away from the paths, so much the better. I have never seen an explanation offered of the reason why poplars are such good conductors of electricity—for mark that when other trees are destroyed the Lombardy poplars will harmlessly take the lightning discharge—but I am of opinion that the extreme moistness of these trees is the reason, combined with the abundance and with the peculiar arrangement of the moist branches. There is no doubt, I think, that lightning when striking a tree does not strike it with one direct and isolated flash, but that the body of the fluid is instantly divided at the moment of striking into almost as many parts as there are branches to receive it. In such trees as the oak and the elm, where in the lower parts there are first the trunk and then large limbs without any covering of twigs or smaller branches, the electric fluid, separated at first by the most topmost twigs, rushes downwards to the channels formed by the drier limbs and trunk. Forced suddenly and accumulated into these confined and congenial passages there is not room for the easy course of the discharge, and disruption ensues. In proof of this theory, it will be remembered that the whole head of a tree is not infrequently broken off by lightning just where the trunk joins the limbs—at the fork—and the trunk and larger limbs always are the sufferers. Now, it will be noticed that the ramification of the Lombardy poplar is, if untouched by the meddling gardener, very peculiar. From base to top the trunk is surrounded by closely-set, densely-clothed branches, or rather branches and twigs, which point upwards. Hence the action of this tree upon a lightning cloud might be likened to that of a sponge. It breaks the force of a discharge by absorbing the fluid, so to speak, at a thousand points, all of which, from their extreme moistness, are excellent conductors. But care must be taken not to plant a Lombardy poplar on one side of a house when there is a pond, a marsh, a stream, or any collection of water immediately on the other side. In such a case a lightning flash might diverge from the tree midway and go through the house to the more attractive water pure and simple; but a pond at the foot of the tree would be an advantage; it would furnish a point of attraction for the electric fluid, and it would make the tree flourish."

THE BRITISH ASSOCIATION MEETING AT MONTREAL.

Section A (Mathematics and Physics) was opened at 11 a.m. on Thursday, Aug. 28, when the President, Sir William Thomson, read the following address:—

The now well-known kinetic theory of gases is a step so important in the way of explaining seemingly static properties of matter by motion, that it is scarcely possible to help anticipating in idea the arrival at a complete theory of matter, in which all its properties will be seen to be merely attributes of motion. If we are to look for the origin of this idea, we must go back to Democritus Epicurus and Lucretius. We may then, I believe, without missing a single step, skip 1,800 years. Early last century we find in Malabranche's "Recherche de la Verité" the statement that "la dureté des corps" depends on "petits tourbillons." These words, embedded in a hopeless mass of unintelligible statements of the physical, metaphysical, and theological philosophies of the day, and unsupported by any explanation, elucidation, or illustration throughout the rest of the three volumes, and only marred by one other single sentence or word to be found in the great book, still do express a distinct conception which forms a most remarkable step towards the kinetic theory of matter. A little later we have Daniel Bernoulli's promulgation of what we now accept as a surest article of scientific faith—the kinetic theory of gases. He, so far as I know, thought only of Boyle's and Marriott's law of the "spring of air," as Boyle called it, without reference to change of temperature or the augmentation of its pressure if not allowed to expand for elevation of temperature, a phenomenon which perhaps he scarcely knew, still less the elevation of temperature produced by compression and the lowering of temperature by dilatation, and the consequent necessity of waiting for a fraction of a second or a few seconds of time (with apparatus of ordinary experimental magnitude), to see a subsidence from a larger change of pressure down to the amount of change that verifies Boyle's law. The consideration of these phenomena 40 years ago by Joule, in connection with Bernoulli's original conception, formed the foundation of the kinetic theory of gases as we now have it. But what a splendid and useful building has been placed on this foundation by Clausius and Maxwell, and what a beautiful ornament we see on the top of it in the radiometer of Crookes, securely attached to it by the happy discovery of Tait and Dewar that the length of the free path of the residual molecules of air in a good modern vacuum may amount to several inches. Clausius' and Maxwell's explanations of the diffusion of gases and thermal conduction in gases, their charmingly intelligible conclusion that in gases the diffusion of heat is just a little more rapid than the diffusion of molecules, because of the interchange of energy in collisions between molecules, while the chief transference of heat is by actual transport of the molecules themselves; and Maxwell's explanation of the viscosity of gases, with the absolute numerical relations which the work of those two great discoverers found among the three properties of diffusion, thermal conduction, and viscosity, have annexed to the domain of science a vast and ever-growing province. Rich as it is in practical results, the kinetic theory of gases as hitherto developed stops absolutely short at the atom or molecule, and gives not even a suggestion towards explaining the properties in virtue of which the atoms or molecules mutually influence one another. For some guidance towards a deeper and more comprehensive theory of matter we may look back with advantage to the end of last century and the beginning of this century, and find Rumford's conclusion regarding the heat generated in boring a brass gun:—"It appears to me to be extremely difficult, if not quite impossible, to form any distinct idea of anything capable of being excited and communicated in the manner the heat was excited and communicated in these experiments, except it be motion;" and Davy's still more suggestive statement, "The phenomena of repulsion are not dependent on a peculiar elastic fluid for their existence. . . ." "Heat may be defined a peculiar motion, probably a vibration, of the corpuscles of bodies, tending to separate them. . . ." "To distinguish this motion from others, and to signify the causes of our sensations of heat, &c., the name 'repulsive' motion has been adopted." Here we have a most important idea. It would be somewhat a bold figure of speech to say the earth and moon are kept apart by a repulsive motion; and yet, after all, what is centrifugal force but a repulsive motion, and may it not be that there is no such thing as repulsion; and that it is solely by inertia that what seems to be repulsion is produced? Two bodies fly together, and, accelerated by mutual attraction, if they do not precisely hit one another, they cannot but separate in virtue of the inertia of their masses. So, after dashing past one another in sharply concave curves round their common centre of gravity, they fly asunder again. A careless onlooker might imagine they had repelled one another, and might not notice the difference between what he actually sees and what he would see if the two bodies had been projected with great velocity towards one another, and either colliding and rebounding, or repelling one another into sharply convex continuous curves, fly asunder again. Joule, Clausius, and Maxwell, and no doubt Daniel Bernoulli himself, and I believe everyone who has hitherto written or done anything very explicit in the kinetic theory of gases, has taken the mutual action of molecules in collision as repulsive. May it not after all be attractive? This idea has never left my mind since I first read Davy's "Repulsive Motion" about thirty-five years ago; but I never made anything of it, at all events have not done so until to-day (June 16, 1884), if

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this can be said to be making anything of it, when in endeavouring to prepare the present address I notice that Joule's and my own old experiments on the thermal effect of gases expanding from a high pressure vessel through a porous plug, prove the less dense gas to have greater intrinsic potential energy than the denser gas, if we assume the ordinary hypothesis regarding the temperature of a gas, according to which two gases are of equal temperatures when the kinetic energies of their constituent molecules are of equal average amounts per molecule. Think of the thing thus. Imagine a great multitude of particles enclosed by a boundary which may be pushed inwards in any part all round at pleasure. Now station an engineer corps of Maxwell's army of sorting demons all round the enclosure, with orders to push in the boundary diligently everywhere when none of the besieged troops are near, and to do nothing when any of them are seen approaching, and until after they have turned again inwards. The result will be that, with exactly the same sum of kinetic and potential energies of the same enclosed multitude of particles, the throng has been caused to be denser. Now Joule's and my own old experiments on the efflux of air prove that if the crowd be common air, or oxygen, or nitrogen, or carbonic acid, the temperature is a little higher in the denser than in the rarer condition when the energies are the same. By the hypothesis, equality of temperature between two different gases or two portions of the same gas at different densities, means equality of kinetic energies in the same number of molecules of the two. From our observations proving the temperature to be higher it therefore follows that the potential energy is smaller in the condensed crowd. This—always, however, under protest as to the temperature hypothesis—proves some degree of attraction among the molecules, but it does not prove ultimate attraction between two molecules in collision, or at distances much less than the average mutual distance of nearest neighbours in the multitude. The collisional force might be repulsive, as generally supposed hitherto, and yet attraction might predominate in the whole reckoning of difference between the intrinsic potential energies of the more dense and less dense multitudes. It is, however, remarkable that the explanation of the propagation of sound through gases, and even of the positive fluid pressure of a gas against the sides or the containing vessel, according to the kinetic theory of gases, is quite independent of the question whether the ultimate collisional force is attractive or repulsive. Of course it must be understood that if it is attractive the particles must be so small that they hardly ever meet—they would have to be infinitely small to never meet: that, in fact, they meet so seldom, in comparison with the number of times their courses are turned through large angles by attraction, that the influence of these purely attractive collisions is preponderant over that of the comparatively very rare impacts from actual contact. Thus, after all, the train of speculation suggested by Davy's "Repulsive Motion" does not allow us to escape from the idea of true repulsion, does not do more than let us say it is of no consequence, nor even say this with truth, because if there are impacts at all the nature of the force during the impact and the effects of the mutual impacts, however rare, cannot be evaded in any attempt to realise a conception of the kinetic theory of gases. And, in fact, unless we are satisfied to imagine the atoms of a gas as mathematical points endowed with inertia, and as, according to Boscovich, endowed with forces of mutual positive and negative attraction, varying according to some definite function of the distance, we cannot avoid the question of impacts, and of vibrations and rotations of the molecules resulting from impacts, and we must look distinctly on each molecule as being either a little elastic solid or a configuration of motion in a continuous all-pervading liquid. I do not myself see how we can ever permanently rest anywhere short of this last view; but it would be a very pleasant temporary resting-place on the way to it, if we could, as it were, make a mechanical model of a gas out of little pieces of round perfectly elastic solid matter flying about through the space occupied by the gas, and colliding with one another and against the sides of the containing vessel. This is, in fact, all we have of the kinetic theory of gases up to the present time, and this has done for us, in the hands of Clausius and Maxwell, the great things which constitute our first step towards a molecular theory of matter. Of course, from it we should have to go on to find an explanation of the elasticity and all the other properties of the molecules themselves, a subject vastly more complex and difficult than the gaseous properties, for the explanation of which we assume the elastic molecule; but without any explanation of the properties of the molecule itself, with merely the assumption that the molecule has the requisite properties, we might rest happy for a while in the contemplation of the kinetic theory of gases and its explanation of the gaseous properties, which is not only stupendously important as a step towards a more thorough-going theory of matter, but is undoubtedly the expression of a perfectly intelligible and definite set of facts in nature. But alas for our mechanical model consisting of the cloud of little elastic solids flying about among one another. Though each particle have absolutely perfect elasticity the end must be pretty much the same as if it were but imperfectly elastic. The average effect of repeated and repeated mutual collisions must be to gradually convert all the translational energy into energy of shriller and shriller vibrations of the molecule. It seems certain that each collision must have something more of energy in vibrations of very finely divided nodal parts than there was of energy of such vibrations before the impact. The more minute this nodal subdivision, the less must be the tendency to give up part of the vibrational energy into the shape of translational energy in the course of a collision, and I think it is rigorously demonstrable that the whole translational energy must ultimately become transformed into vibrational energy of higher and higher nodal subdivisions if each molecule is a continuous elastic solid. Let us, then, leave the kinetic theory of gases for a time with this difficulty unsolved, in the hope that we or others after us may return to it, armed with more knowledge of the properties of matter, and with sharper mathematical weapons to cut through the barrier which at present hides from us any view of the molecule itself, and of the effects other than mere change of translational motion which it experiences in collision. To explain the elasticity of a gas was the primary object of the kinetic theory of gases. This object is only attainable by the assumption of an elasticity more complex in character, and more difficult of explanation, than the elasticity of gases—the elasticity of a solid. Thus, even if the fatal fault in the theory to which I have alluded did not exist, and if we could be perfectly satisfied with the kinetic theory of gases founded on the collisions of elastic solid molecules, there would still be beyond it a grander theory—which need not be considered a chimerical object of scientific ambition—to explain the elasticity of solids. But we may be stopped when we commence to look in the direction of such a theory with the cynical question, What do you mean by explaining a property of matter? As to being stopped by any such question, all I can say is that if engineering were to be all and to end all physical science, we should perforce be content with merely finding properties of matter by observation, and using them for practical purposes. But I am sure very few, if any, engineers are practically satisfied with so narrow a view of their noble profession. They must and do patiently observe, and discover by observation, properties of matter, and results of material combinations. But deeper questions are always present, and always fraught with interest to the true engineer, and he will be the last to give weight to any other objection to any attempt to see below the surface of things than the practical question, Is it likely to prove wholly futile? But now, instead of imagining the question, What do you mean by explaining a property of matter? to be put cynically, and letting ourselves be irritated by it, suppose we give to the questioner credit for being sympathetic, and condescend to try and answer his question. We find it not very easy to do so. All the properties of matter are so connected that we can scarcely imagine one thoroughly explained without our seeing its relation to all the others, without, in fact, having the explanation of all, and till we have this we cannot tell what we mean by "explaining a property," or "explaining the properties" of matter. But though this consummation may never be reached by man, the progress of science may be—I believe will be—step by step towards it, on many different roads converging towards it from all sides. The kinetic theory of gases is, as I have said, a true step on one of the roads. On the very distinct road of chemical science, St. Clair Deville arrived at his grand theory of dissociation without the slightest aid from the kinetic theory of gases. The fact that he worked it out solely from chemical observation and experiment and expounded it to the world without any hypothesis whatever, and seemingly even without consciousness of the beautiful explanation it has in the kinetic theory of gases, secured for it immediately an independent solidity and importance as a chemical theory when he first promulgated it, to which it might even by this time scarcely have attained if it had first been suggested as a probability indicated by the kinetic theory of gases, and been only afterwards confirmed by observation. Now, however, guided by the views which Clausius and Williamson have given us of the continuous interchange of partners between the compound molecules constituting chemical compounds in the gaseous state, we see in Deville's theory of dissociation a point of contact of the most transcendent interest between the chemical and physical lines of scientific progress. To return to elasticity. If we could make out of matter devoid of elasticity a combined system of relatively moving parts, which, in virtue of motion, has the essential characteristics of an elastic body, this would surely be, if not positively a step in the kinetic theory of matter, at least a finger post pointing a way which we may hope will lead to a kinetic theory of matter. Now this, as I have already shown, we can do in several ways. In the case of the last of the communications referred to, of which only the title has hitherto been published, I showed that, from the mathematical investigation of a gyrostatically dominated combination contained in the passage of Thomson and Tait's "Natural Philosophy," referred to, it follows that any ideal system of material particles, acting on one another mutually through massless connecting springs, may be perfectly imitated in a model consisting of rigid links jointed together, and having rapidly rotating fly-wheels pivoted on some or on all of the links. The imitation is not confined to cases of equilibrium. It holds also for vibration produced by disturbing the system infinitesimally from a position of stable equilibrium and leaving it to itself. Thus we may make a gyrostatic system such that it is in equilibrium under the influence of certain positive forces applied to different points of this system; all the forces being precisely the same as, and the points of application similarly situated to, those of the stable system with springs. Then, provided proper masses (that is to say, proper amounts and distributions of inertia) be attributed to the links, we may remove the external forces from each system, and the consequent vibration of the points of application of the forces will be indentical. Or we may act upon the systems of material points and springs with any given forces for any given time, and leave it to itself, and do the same thing for the gyrostatic system; the consequent motion will be the same in the two cases. If in the one case the springs are made more and more stiff, and in the other case the angular velocities of the fly-wheels are made greater and greater, the periods of the vibrational constituents of the motion will become shorter and shorter, and the amplitudes smaller and smaller, and the motions will approach more and more nearly those of two perfectly rigid groups of material points, moving through space and rotating according to the well known mode of rotation of a rigid body having unequal moments of inertia about its three principal axes. In one case the ideal nearly rigid connections between the particles is produced by massless exceedingly stiff springs; in the other case it is produced by the exceedingly rapid rotation of the fly-wheels in a system which, when the fly-wheels are deprived of their rotation, is perfectly limp. The drawings (Figs. 1 and 2) before you illustrate two such material systems. In Fig. 1 the two hooked rods seen projecting from the sphere are connected by an elastic coach spring. In Fig. 2 the hooked rods are con

nected one to each of two opposite corners of a four-sided jointed frame, each member of which carries a gyrostat, so that the axis of rotation of the fly-wheel is in the axis of the member of the frame which bears it. Each of the hooked rods in Fig. 2 is connected to the framework through a swivel joint, so that the whole gyrostatic framework may be rotated about the axis of the hooked rods in order to annul the moment of momentum of the framework about this axis due to rotation of the fly-wheels in the gyrostats. The directions of rotation of the fly-wheels in the gyrostatic system (Fig. 2) are indicated by directional ellipses, which show in perspective the direction of rotation of the fly-wheel of each gyrostat. The gyrostatic system (Fig. 2) might have been constituted of two gyrostatic members, but four are shown for symmetry. The enclosing circle represents in each case in section an enclosing spherical shell to prevent the interior from being seen. In the inside of one there are fly-wheels, in the inside of the other a massless spring. The projecting hooked rods seem as if they are connected by a spring in each case. If we hang any one of the systems up by the hook on one of its projecting rods, and hang a weight to the hook of the other projecting rod, the weight when first put on will oscillate up and down, and will go on doing so for ever if the system be absolutely unfrictional. If we check the vibration by hand, the weight will hang down at rest, the pin drawn out to a certain degree; and the distance drawn out will be simply proportional to the weight hung on, as in an ordinary spring balance. Here, then, out of matter possessing rigidity, but absolutely devoid of elasticity, we have made a perfect model of a spring in the form of a spring-balance. Connect millions of millions of particles by pairs of rods such as these of this spring balance, and we have a group of particles constituting an elastic solid, exactly fulfilling the mathematical ideal worked out by Navier, Poisson, and Cauchy, and many other mathematicians who, following their example, have endeavoured to found a theory of the elasticity of solids on mutual attraction and repulsion between a group of material particles. All that can possibly be done by this theory, with its assumption of forces acting according to any assumed law of relation to distance, is done by the gyrostatic system. But the gyrostatic system does, besides, what the system of naturally acting material particles cannot do, it constitutes an elastic solid which

FIG. 1

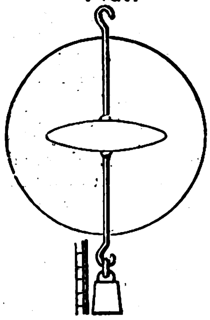
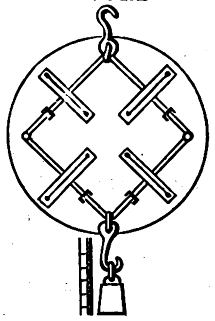


FIG. 2



can have the Faraday magneto-optic rotation of the plane of polarisation of light, supposing the application of our solid to be a model of the luminiferous ether for illustrating the undulatory theory of light. The gyrostatic model spring-balance is arranged to have zero moment of momentum as a whole, and therefore to contribute nothing to the Faraday rotation; with this arrangement the model illustrates the luminiferous ether in a field unaffected by magnetic force. But now let there be a different rotational velocity imparted to the jointed square round the axis of the two projecting hooked rods, such as to give a resultant moment of momentum round any given line through the centre of inertia of the system, and let pairs of the hooked rods in the model thus altered, which is no longer a model of a mere spring-balance, be applied as connections between millions of pairs of particles as before—with the lines of resultant moment of momentum all similarly directed. We now have a model elastic solid which will have the property that the direction of vibration in waves of rectilinear vibrations propagated through it shall turn round the line of propagation of the waves; just as Faraday's observation proves to be done by the line of vibration of light in a dense medium between the poles of a powerful magnet. The case of wave front perpendicular to the lines of resultant moment of momentum (that is to say, the direction of propagation being parallel to these lines) corresponds, in our mechanical model, to the case of light travelling in the direction of the lines of force in a magnetic field. In these illustrations and models we have different portions of ideal rigid matter acting upon one another, by normal pressure at mathematical points of contact—of course, no forces of friction are supposed. It is exceedingly interesting to see how thus, with no other postulates than inertia, rigidity, and mutual impenetrability, we can thoroughly model not only an elastic solid, and any combination of elastic solids, but so complex and recondite a phenomenon as the passage of polarised light through a magnetic field. But now, with the view of ultimately discarding the postulate of rigidity from all our materials, let us suppose some to be absolutely destitute of rigidity, and to possess merely inertia and incompressibility, and mutual impenetrability with reference to the still remaining rigid matter. With these postulates we can produce a perfect model of mutual action at a distance between solid particles, fulfilling the condition, so keenly desired by Newton and Faraday, of being explained by continuous action through an intervening medium. The law of the mutual force in our model, however, is not the simple Newtonian law, but the much more complex law of the mutual action between two electro-magnets—with this difference, that in the hydro-kinetic model in every case the force is opposite in direction to the corresponding force in the electro-magnetic analogue. Imagine a solid bored through with a hole and placed in our ideal perfect liquid. For a moment let the hole be stopped by a diaphragm, and let an impulsive pressure be applied for an instant uniformly over the whole membrane, and then instantly let the membrane be dissolved into liquid. This action originates a motion of the liquid relatively to the solid, of a kind to which I have given the name of "irrotational circulation," which remains absolutely constant however the solid be moved through the liquid. Thus, at any time the actual motion of the liquid at any point in the neighbourhood of the solid will be the resultant of the motion it would have in virtue of the circulation alone were the solid at rest, and the motion it would have in virtue of the motion of the solid itself had there been no circulation established through the aperture. It is interesting and important to remark in passing that the whole kinetic energy of the liquid is the sum of the kinetic energies which it would have in the two cases separately. Now, imagine the whole liquid to be enclosed in an infinitely large rigid containing vessel, and in the liquid, at an infinite distance from any part of the containing vessel, let two perforated solids, with irrotational circulation through each, be placed at rest near one another. The resultant fluid motion due to the two circulations will give rise to fluid pressure on the two bodies, which if unbalanced will cause them to move. The force systems—force-and-torques, or pairs of forces—required to prevent them from moving will be mutual and opposite, and will be the same as, but opposite in direction to, the mutual force systems required to hold at rest two electro-magnets fulfilling the following specification. The two electro-magnets are to be of the same shape and size as the two bodies, and to be placed in the same relative positions, and to consist of infinitely thin layers of electric currents in the surfaces of solids possessing extreme diamagnetic quality—in other words, infinitely small permeability. The distribution of electric current on each body may be any whatever which fulfils the condition that the total current across any closed line drawn on the surface once through the aperture is equal to $\frac{1}{4\pi}$ of the circulation through the aperture in the hydro-kinetic analogue. It might be imagined that the action at a distance thus provided for by fluid motion could serve as a foundation for a theory of the equilibrium and the vibrations of elastic solids, and the transmission of waves like those of light through an extended *quasi*-elastic solid medium. But, unfortunately for this idea, the equilibrium is essentially unstable, both in the case of magnets and, notwithstanding the fact that the forces are oppositely directed, in the hydro-kinetic analogue also, when the several movable bodies (two or any greater number) are so placed relatively as to be in equilibrium. If, however, we connect the perforated bodies with circulation through them in the hydro-kinetic system by jointed rigid connecting links we may arrange for configurations of stable equilibrium. Thus without fly-wheels, but with fluid circulations through apertures, we may make a model spring-balance, or a model luminiferous ether, either without or with the rotational quality corresponding to that of the true luminiferous ether in the magnetic fluid—in short, do all by the perforated solids with circulations through them that we saw we could do by means of linked gyrostats. But something that we cannot do by linked gyrostats we can do by the perforated bodies with fluid circulation. We can make a model gas. The mutual action at a distance, repulsive or attractive according to the mutual aspect of the two bodies when passing within collisional distance of one another, suffices to produce the change of direction of motion in collision which essentially constitutes the foundation of the kinetic theory of gases; and which, as we have seen before, may as well be due to attraction as to repulsion, so far as we know from any investigation hitherto made in this theory. There remains, however, as we have seen before, the difficulty of providing for the case of actual impacts between the solids, which must be done by giving them massless spring buffers, or, which amounts to the same thing, attributing to them repulsive forces sufficiently powerful at very short distances to absolutely prevent impacts between solid and solid, unless we adopt the equally repugnant idea of infinitely small perforated solids with infinitely great fluid circulations through them. Were it not for this fundamental difficulty the hydro-kinetic model gas would be exceedingly interesting; and, though we could scarcely adopt it as conceivably a true representation of what gases really are, it might still have some importance as a model configuration of solid and liquid matter, by which without elasticity the elasticity of a true gas might be represented. But, lastly, since the hydro-kinetic model gas with perforated solids and fluid circulations through them fails because of the impacts between the solids, let us annul the solids and leave the liquid performing irrotational circulation round vacancy, in the place of the solid cores which we have hitherto supposed; or let us annul the rigidity of the solid cores of the rings and give them molecular rotation according to Helmholtz's theory of vortex motion. For stability the molecular rotation must be such as to give the same velocity at the boundary of the rotational fluid core as that of the irrotationally circulating liquid in contact with it, because, as I have proved, frictional slip between two portions of liquid in contact is inconsistent with stability. There is a further condition upon which I cannot enter in detail just now, but which may be understood in a general way when I say that it is a condition of either uniform or of increasing molecular rotation from the surface inwards analogous to the condition that the density of a liquid, resting for example under the influence of gravity, must either be uniform or must be greater below than above for stability of equilibrium. All that I have said in favour of the model vortex gas composed of perforated solids with fluid circulations through them holds without modification for the purely hydro-kinetic model composed of either Helmholtz cored vortex rings or of coreless vortices, and we are now troubled

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with no such difficulty as that of the impacts between solids. Whether, however, when the vortex theory of gases is thoroughly worked out it will or will not be found to fail in a manner analogous to the failure which I have already pointed out in connection with the kinetic theory of gases composed of little elastic solid molecules, I cannot at present undertake to speak with certainty. It seems to me most probable that the vortex theory cannot fail in any such way, because all I have been able to find out hitherto regarding the vibration of vortices, whether cored or coreless, does not seem to imply the liability of translational or impulsive energies of the individual vortices becoming lost in energy of smaller and smaller vibrations. As a step towards kinetic theory of matter it is certainly most interesting to remark that in the quasi-elasticity—elasticity looking like that of an india rubber band which we see in a vibrating smoke-ring launched from an elliptic aperture, or in two smoke-rings which were circular, but which have become deformed from circularity by mutual collision, we have in reality a virtual elasticity in matter devoid of elasticity, and even devoid of rigidity, the virtual elasticity being due to motion and generated by the generation of motion.

Section B (Chemistry) met at noon on Thursday, when Professor Sir Henry Roscoe read the presidential address, which was as follows :—

With the death of Berzelius in 1848 ended a well-marked epoch in the history of our science ; with that of Dumas—and, alas ! that of Wurtz also—in 1884 closes a second. It may not perhaps be unprofitable on the present occasion to glance at some few points in the general progress which chemistry has made during this period, and thus to contrast the position of the science in the "Sturm und Drang" year of 1848 with that in the present perhaps quieter period. The differences between what may properly be termed the Berzelian era and that with which the name of Dumas will for ever be associated show themselves in many ways, but in none more markedly than by the distinct views entertained as to the nature of a chemical compound. According to the older notions the properties of compounds are essentially governed by the qualitative nature of their constituent atoms, which were supposed to be so arranged as to form a binary system. Under the new ideas, on the other hand, it is mainly the number and arrangement of the atoms within the molecule, which regulate the characteristics of the compound, which is to be looked on not as built up of two constituent groups of atoms, but as forming one group. Among those who successfully worked to secure this important change of view on a fundamental question of chemical theory the name of Dumas himself must first be mentioned, and, following upon him, the great chemical twin-brethren, Laurent and Gerhardt, who, using both the arguments of test-tube and of pen in opposition to the prevailing views, gradually succeeded, though scarcely during the lifetime of the first, in convincing chemists that the condition of things could hardly be a healthy one when chemistry was truly defined "as the science of bodies which do not exist." For Berzelius, adhering to his preconceived notions, had been forced by the pressure of new discovery into the adoption of formulæ which gradually became more and more complicated, and led to more and more doubtful hypotheses, until his followers at last could barely succeed in building up the original radical from its numerous supposed component parts. Such a state of things naturally brought about its own cure, and the unitary formulæ of Gerhardt began to be generally adopted. There is another change of view, dating from the commencement of the Dumas epoch, which has exerted an influence equal, if not superior, to those already named on the progress of our science. The relative weights of the ultimate particles, to use Dalton's own words, which up to this time had been generally adopted by chemists, were the equivalent weights of Dalton and Wollaston, representing, in the case of oxygen and hydrogen, the proportions in which these elements combine, viz., as 8 to 1. The great Swedish chemist at this time stood almost alone in supporting another hypothesis ; for, founding his argument on the simple laws of volume-combination enunciated by Gay-Lussac, he asserted that the true atomic weights are to be represented by the relations existing between equal volumes of the two gases, viz., as 16 to 1. Still these views found no favour in the eyes of chemists until Gerhardt, in 1843, proposed to double the equivalent weights of oxygen, sulphur, and carbon, and then the opposition which this suggestion met with was most intense, Berzelius himself not even deigning to mention it in his annual account of the progress of the science, thus proving the truth of his own words : "That to hold an opinion habitually often leads to such an absolute conviction of its truth that its weak points are unregarded, and all proofs against it ignored." Nor were these views generally adopted by chemists until Cannizaro, in 1858, placed the whole subject on its present firm basis by clearly distinguishing between equivalent and molecular weights, showing how the atomic weights of the constituent elements are derived from the molecular weights of their volatile compounds based upon the law of Avogadro and Ampère, or where, as is the case with many metals, no compounds of known vapour-density exist, how the same result may be ascertained by the help of the specific heat of the element itself. Remarkable as it may appear, it is, nevertheless, true that it is in the country of their birth that Gerhardt's atomic weights and the consequent atomic nomenclature have met with most opposition, so much so that within a year or two of the present time there was not a single course of lectures delivered in Paris in which these were used. At the Edinburgh meeting of this Association in 1850, Williamson read a paper on "Results of a Research on Ætherification," which included not only a satisfactory solution of an interesting and hitherto unexplained problem, but was destined to exert a most important influence on the development of our theoretical views. For he proved, contrary to the then prevailing ideas, that ether contains twice as much carbon as alcohol, and that it is not formed from the latter by a mere separation of the elements of water, but by an exchange of hydrogen for ethyl, and this fact being in accordance with Avogadro's law of molecular volumes, could only be represented by regarding the molecule of water as containing two atoms of hydrogen to one of oxygen, one of the former being replaced by one of ethyl to form alcohol, and the two of hydrogen by two of ethyl to form ether. Then Williamson introduced the type of water (subsequently adopted by Gerhardt) into organic chemistry, and extended our views of the analogies between alcohols and acids, by pointing out that these latter are also referable to the water-type, predicting that bodies bearing the same relations to the ordinary acids as the ethers do to the alcohols must exist, a prediction shortly afterwards (1852) verified by Gerhardt's discovery of the anhydrides. Other results followed in rapid succession, all tending to knit together the framework of modern theoretical chemistry. Again, in 1852, we note the first germs of a theory which was destined to play an all-important part in the progress of the science, viz., the doctrine of valency or atomicity, and to Frankland it is that we owe this new departure. Singularly enough, while considering the symmetry of construction visible among the inorganic compounds of nitrogen, phosphorus, arsenic, and antimony, and while putting forward the fact that the combining power of the attracting element is always satisfied by the same number of atoms, he does not point out the characteristic tetrad nature of carbon ; and it was not until 1858 that Couper initiated, and Kekulé in the same year thoroughly established, the doctrine of the linking of the tetrad carbon atoms, a doctrine to which, more than to any other, is due the extraordinary progress which organic chemistry has made during the last 20 years, a progress so vast that it is already found impossible for one individual, even though he devote his whole time and energies to the task, to master all the details, or make himself at home with the increasing mass of new facts which the busy workers in this field are daily bringing forth. The subject of the valency of the elements is one which, since the year above referred to, has given chemists much food for discussion, as well as opportunity for experimental work. But whether we range ourselves with Kekulé, who supports the unalterable character of the valency of each element, or with Frankland, who insists on its variability, it is now clear to most chemists that the hard and fast lines upon which this theory was supposed to stand cannot be held to be secure. For if the progress of investigation has shown that it is impossible in many instances to affix one valency to an element which forms a large number of different compounds, it is also equally impossible to look on the opposite view as tending towards progress, inasmuch as to ascribe to an element as many valencies as it possesses compounds with some other element, is only expressing by circuitous methods what the old Daltonian law of combination in multiple proportions states in simple terms. But, however many doubts have been raised in special instances against a thorough application of the law of valency, it cannot be denied that the general relations of the elements which this question of valency has been the means of bringing to light are of the highest importance, and point to the existence of laws of nature of the widest significance ; I allude to the periodic law of the elements first foreshadowed by Newlands, but fully developed by Mendelejeff and Lothar Meyer. Guided by the principle that the chemical properties of the elements are a periodic function of their atomic weights, or that matter becomes endowed with analogous properties when the atomic weight of an element is increased by the same or nearly the same number, we find ourselves for the first time in possession of a key which enables us to arrange the hitherto *disjecta membra* of our chemical household in something like order, and thus gives us means of indicating the family resemblances by which these elements are characterised. And here we may congratulate ourselves on the fact that, by the recent experiments of Brauner, and of Nilson and Petterson respectively, tellurium and beryllium, two of the hitherto outstanding members, have been induced to join the ranks, so that at the present time osmium is the only important defaulter among the 64 elements, and few persons will doubt that a little careful attention to this case will remove the stigma which yet attaches to its name. But this periodic law makes it possible for us to do more ; for as the astronomer, by the perturbations of known planets, can predict the existence of hitherto unknown ones, so the chemist, though, of course, with much less satisfactory means, has been able to predict with precision the properties, physical and chemical, of certain missing links among the elements, such as ekaluminium and ekaboron, then unborn, but which shortly afterwards became well known to us in the flesh as gallium and scandium. We must, however, take care that success in a few cases does not blind us to the fact that the law of nature which expresses the relation between the properties of the elements and the value of the atomic weights is as yet unknown ; that many of the groupings are not due to any well ascertained analogy of properties of the elements, and that it is only because the values of their atomic weights exhibit certain regularities that such a grouping is rendered possible. Passing from this subject, we arrive, by a process of natural selection, at more complicated cases of chemical orientation—that is, given certain compounds which possess the same composition and molecular formulæ but varying properties, to find the difference in molecular structure by which such variation of properties is determined. Problems of this nature can now be satisfactorily solved, the number of possible isomers foretold, and this prediction confirmed by experiment. The general method adopted in such an experimental inquiry into the molecular arrangement or chemical constitution of a given compound is either to build up the structure from less complicated ones of known constitution, or to resolve it into such component parts. The discovery of the aniline colours by Perkin, their elaboration by Hoffmann, the synthesis of alizarin by Graebe and Liebermann, being the first vegetable colouring matter which has been artificially obtained, the artificial production of indigo by Baeyer, and lastly the preparation by Fischer, of kairine, a febrifuge as potent as quinine, are some of the well-known recent triumphs of modern synthetical chemistry. And these

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triumphs, let us remember, have not been obtained by any such "random haphazarding" as yielded results in Priestley's time. In the virgin soil of a century ago, the ground only required to be scratched and the seed thrown in to yield a fruitful crop; now the surface soil has long been exhausted, and the successful cultivator can only obtain results by a deep and thorough preparation, and by a systematic and scientific treatment of his material. In no department of our science has the progress made been more important than in that concerned with the accurate determination of the numerical, physical, and chemical constants upon the exactitude of which every quantitative chemical operation depends. For the foundation of an accurate knowledge of the first of these constants—viz., the atomic weights of the elements, science is indebted to the indefatigable labours of Berzelius. But *humanum est errare*, and even Berzelius's accurate hand and delicate conscientiousness did not preserve him from mistakes, since corrected by other workers. In such determinations it is difficult, if not impossible, always to ascertain the limits of error attaching to the number. The errors may be due, in the first place, to manipulative faults; in the second, to inaccuracy of the methods; or, lastly, to mistaken views as to the composition of the material operated upon; and hence the uniformity of any series of similar determinations gives no guarantee of their truth, the only safe guide being the agreement of determinations made by altogether different methods. The work commenced by Berzelius has been worthily continued by many chemists. Since the date of Berzelius's death to the present day no discovery in our science has been so far-reaching, or led to such unforeseen and remarkable conclusions, as the foundation of spectrum analysis by Bunsen and Kirchoff in 1860. Independently altogether of the knowledge which has been gained concerning the distribution of the elementary bodies in terrestrial matter, and of the discovery of half-a-dozen new elements by its means, and putting aside for a moment the revelation of a chemistry not bounded by this world, but limitless as the heavens, we find that over and above all these results spectrum analysis offers the means, not otherwise open to us, of obtaining knowledge concerning the atomic and molecular condition of matter. Let me recall some of the more remarkable conclusions to which the researches of Lockyer, Schuster, Liveing and Dewar, Wülner and others in this direction have led. In the first place it is well to bear in mind that a difference of a very marked kind, first distinctly pointed out by Alex. Mitscherlich, is to be observed between the spectrum of an element and that of its compounds, the latter only being seen in cases in which the compound is not dissociated at temperatures necessary to give rise to a glowing gas. Secondly, that these compound spectra—as, for instance, those of the halogen compounds of the alkaline-earth metals—exhibit a certain family likeness, and show signs of systematic variation in the position of the lines, corresponding to changes in the molecular weight of the vibrating system. Still this important subject of the relation of the spectra of different elements is far from being placed on a satisfactory basis, and in spite of the researches of Lecoq de Boisbaudran, Ditte, Troost and Hautefeuille, Ciamician and others, it cannot be said that as yet definite proof has been given in support of the theory that a casual connection is to be found between the emission spectra of the several elements belonging to allied groups and their atomic weights or other chemical or physical properties. In certain of the single elements, however, the connection between the spectra and the molecular constitution can be traced. In the case of sulphur, for example, three distinct spectra are known. The first of these, a continuous one, is exhibited at temperatures below 500deg., when, as we know from Dumas' experiments, the density of the vapour is three times the normal, showing that at this temperature the molecule consists of six atoms. The second spectrum is seen when the temperature is raised to above 1,000deg., when, as Deville and Troost have shown, the vapour reaches its normal density, and the molecule of sulphur, as with most other gases, contains two atoms, and this is a band spectrum, or one characterised by channelled spaces. Together with this band spectrum, and especially round the negative pole, a spectrum of bright lines is observed. This latter is doubtless due to the vibrations of the single atoms of the dissociated molecule, the existence of traces of a band spectrum demonstrating the fact that in some parts of the discharge the tension of dissociation is insufficient to prevent the reunion of the atoms to form the molecule. To this instance of the light thrown on molecular relations by changes in the spectra others may be added. Thus the low-temperature spectrum of channelled spaces, mapped by Schuster and myself, in the case of potassium, corresponds to the molecule of two atoms and to the vapour-density of seventy-nine, as observed by Dewar and Dittmar. Again, both oxygen and nitrogen exhibit two, if not three, distinct spectra; of these the line spectrum seen at the highest temperatures corresponds to the atom; the band spectrum seen at intermediate temperatures represents the molecule of two atoms; while that observed at a still lower point would, as in the case of sulphur, indicate the existence of a more complicated molecule, known to us in one instance as ozone. That this explanation of the cause of these different spectra of an element is the true one can be verified in a remarkable way. Contrary to the general rule, among those elements which can readily be volatilised, and with which, therefore, low-temperature spectra can be studied, mercury exhibits but one spectrum, and that one of bright lines, or, according to the preceding theory, a spectrum of atoms. So that, judging from spectroscopic evidence, we infer that the atoms of mercury do not unite to form a molecule, and we should predict that the vapour-density of mercury is only half its atomic weight. Such we know, from chemical evidence, is really the case, the molecule of mercury being identical in weight with its atom. The cases of cadmium and iodine require further elucidation. The molecule of gaseous cadmium, like that of mercury, consists of one atom; probably, therefore, the cadmium spectrum is also distinguished by one set of lines. Again, the molecule of iodine at 1,200deg. separates, as we know from Victor Meyer's researches, into single atoms. Here spectrum analysis may come again to our aid; but as Schuster remarks, in his report on the spectra of the non-metallic elements, a more extensive series of experiments than those already made by Ciamician is required before any definite opinion as to the connection of the different iodine spectra with the molecular condition of the gas can be expressed. It is not to be wondered at that these relations are only exhibited in the case of a few elements. For most of the metals the vapour-density remains, and probably will remain, an unknown quantity, and therefore the connection between any observed changes in the spectra and the molecular weights must also remain unknown. The remarkable changes which the emission spectrum of a single element—iron, for instance—exhibits have been the subject of much discussion, experimental and otherwise. Of these, the phenomenon of long and short lines is one of the most striking, and the explanation that the long lines are those of low temperature appears to meet the facts satisfactorily, although the effect of dilution, that is a reduction of the quantity of material undergoing volatilisation, is, remarkably enough, the same as that of diminution of temperature. Thus it is possible, by the examination of a spectrum by Lockyer's method, to predict the changes which it will undergo, either on alteration of temperature or by an increase or decrease of quantity. There appears to be no theoretical difficulty in assuming that the relative intensity of the lines may vary when the temperature is altered, and the molecular theory of gases furnishes us with a plausible explanation of the corresponding change when the relative quantities of the luminous elements in a mixture are altered. Lockyer has proposed a different explanation of the facts. According to him, every change of relative intensity means a corresponding change of molecular complexity, and the lines which we see strong near the poles would bear the same relation to those which are visible throughout the field, as a line spectrum bears to a band spectrum; but then, almost every line must be due to a different molecular grouping, a conclusion which is scarcely capable of being upheld without very cogent proof. The examination of the absorption spectra of salts, saline, and organic liquids, first by Gladstone and afterwards by Bunsen, and by Russell, as well as by Hartley for the ultra-violet, and by Abney and Festing for the infra-red region, have led to interesting results in relation to molecular chemistry. Thus Hartley finds that in some of the more complicated aromatic compounds, definite absorption bands in the more refrangible region are only produced by substances in which three pairs of carbon atoms are doubly linked, as in the benzene ring, and thus the means of ascertaining this double linkage is given. The most remarkable results obtained by Abney and Festing show that the radical of an organic body is always represented by certain well-marked absorption bands, differing, however, in position, according as it is linked with hydrogen, a halogen, or with carbon, oxygen, or nitrogen. Indeed, these experimenters go so far as to say that it is highly probable that by this delicate mode of analysis the hypothetical position of any hydroden which is replaced may be identified, thus pointing out a method of physical orientation, of which, if confirmed by other observers, chemists will not be slow to avail themselves. This result, it is interesting to learn, has been rendered more than probable by the recent important researches of Perkin on the connection between the constitution and the optical properties of chemical compound. One of the noteworthy features of chemical progress is the interest taken by physicists in fundamental questions of our science. We all remember, in the first place, Sir William Thomson's interesting speculations, founded upon physical phenomena, respecting the probable size of the atom—viz., "That if a drop of water were magnified to the size of the earth, the constituent atoms would be larger than small shot, but smaller than cricket balls." Again, Helmholtz in the Faraday lecture, delivered in 1881, discusses the relation of electricity and chemical energy, and points out that Faraday's law of electrolysis, and the modern theory of valency, are both expressions of the fact, that when the same quantity of electricity passes through an electrolyte, it always either sets free, or transfers to other combinations, the same number of units of affinity at both electrodes. Helmholtz further argues, that if we accept the Daltonian atomic hypothesis, we cannot avoid the conclusion that electricity, both positive and negative, is divided into elementary portions, which behave like atoms of electricity. He also shows that these charges of atomic electricity are enormously large as compared, for example, with the attraction of gravitation between the same atoms—in the case of oxygen and hydrogen, 71,000 billion times larger. A further subject of interest to chemists is the theory of the vortex-ring constitution of matter thrown out by Sir William Thomson, and lately worked out from a chemical point of view by J. J. Thomson, of Cambridge. He finds that if one such ring be supposed to constitute the most simple form of matter, say the monad hydrogen atom, then two such rings must, on coming into contact with nearly the same velocity, remain enchained together, constituting what we know as the molecule of free hydrogen. So, in like manner, systems containing two, three, and four such rings constitute the dyad, triad, and tetrad atoms. How far this mathematical expression of chemical theory may prove consistent with fact remains to be seen. In conclusion, while far from proposing even to mention all the important steps by which our science has advanced since the year 1848, I cannot refrain from referring to two more—in the first place, to that discovery, more than foreshadowed by Faraday, of the liquefaction of the so-called permanent gases by Pictet and Cailletet; and, secondly, to that of the laws of dissociation as investigated by Deville. The former, including Andrews's discovery of the critical point, indicates a connection, long unseen, between the liquid and the gaseous states of matter; the latter has opened out entirely fresh fields for research, and has given us new views concerning the stability of chemical compounds of great importance and interest. Turning for a moment to another topic, we feel that, although science knows no nationalities, it is impossible for those who like ourselves exhibit strong national traits to avoid asking whether we Anglo-Saxons hold our own, as compared with other nations, in the part we have played and are playing in the development of our science. With regard to the past, the

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names of Boyle, Cavendish, Priestley, Dalton, Black, Davy, are sufficient guarantees that the English have, to say the least, occupied a position second to none in the early annals of chemistry. How has it been in the era which I have attempted to describe? What is the present position of English chemistry, and what its look-out for the future? In endeavouring to make this estimate I would take the widest ground, including not only the efforts made to extend the boundaries of our science by new discovery, both in the theoretical and applied branches, but also those which have the no less important aims of spreading the knowledge of the subject among the people, and of establishing industries dependent on chemical principles by which the human race is benefited. Taking this wide view, I think we may, without hesitation, affirm that the progress which chemistry has made through the energies of the Anglo-Saxon race is not less than that made by any other nation. In so far as pure science is concerned, I have already given evidence of the not inconsiderable part which English chemists have played in its progress since 1848. We must, however, acknowledge that the number of original chemical papers now published in our language is much smaller than that appearing in the German tongue, and that the activity and devotion displayed in this direction by the heads of German laboratories may well be laid to heart by some of us in England; yet, on the other hand, it must be remembered that the circumstances of different countries are so different that it is by no means clear that we should follow the same lines. Indeed, our national characteristics forbid us to do so, and it may be that the bent of the German lies in the assiduous collection of facts, while their subsequent elaboration and connection is the natural work of our own race. As regards the publication of so-called original work by students, and speaking now only for myself as the director of an English chemical laboratory, I feel I am doing the best for the young men who, wishing to become either scientific or industrial chemists, are placed under my charge, in giving them as sound and extensive a foundation in the theory and practice of chemical science as their time and abilities will allow, rather than forcing them prematurely into the preparation of a new series of homologous compounds, or the investigation of some special reaction, or of some possible new colouring matter, though such work might doubtless lead to publication. My aim has been to prepare a young man, by a careful and fairly complete general training, to fill with intelligence and success a post either as teacher or industrial chemist, rather than to turn out mere specialists who, placed under other conditions than those to which they have been accustomed, are unable to get out of the narrow groove in which they have been trained. And this seems a reasonable course, for while the market for the pure specialist, as the colour chemist for example, may easily be overstocked, the man of all-round intelligence will always find opportunity for the exercise of his powers. Far, however, from underrating the educational advantages of working at original subjects, I consider this sort of training to be of the highest and best kind, but only useful when founded upon a sound and general basis. The difficulty which the English teacher of chemistry, and in this I may include Canada and the United States, has to contend with is, that while in Germany the value of this high and thorough training is generally admitted, in England a belief in its efficacy is as yet not generally entertained. "The Englishman," to quote from the recent report of the Royal Commission on Technical Instruction, "is accustomed to seek for an immediate return, and has yet to learn that an extended and systematic education, up to and including the methods of original research, is now a necessary preliminary to the fullest development of industry, and it is to the gradual but sure growth of public opinion in this direction that we must look for the means of securing to this country in the future, as in the past, the highest position as an industrial nation." If, in the second place, we consider the influence which Englishmen have exerted on the teaching of our science, we shall feel reason for satisfaction; many of our text-books are translated into every European language and largely used abroad; often to the exclusion of those written by Continental chemists. Again, science teaching, both practical and theoretical, in our elementary and many secondary schools is certainly not inferior to that in schools of similar grade abroad, and the interest in and desire for scientific training are rapidly spreading throughout our working population, and are even now as great as, if not greater than, abroad. The universities and higher colleges are also moving to take their share of the work, which has hitherto been far less completely done in our country than on the Continent of Europe, especially in Germany, where the healthful spirit of competition, fostered by the numerous State-supported institutions, is much more common than with us, and, being of equal value in educational as in professional or commercial matters, has had its due effect. Turning lastly to the practical applications of our science, in what department does England not excel; and in which has she not made the most important new departures? Even in colour chemistry, concerning which we have heard, with truth, much of German supremacy, we must remember that the industry is originally an English one, as the names of Perkin, Maule, Simpson, and Nicholson testify; and if we have hitherto been beaten hollow in the development of this branch, signs are not wanting that this may not always be the case. But take any other branch of applied chemistry, the alkali trade, for instance, what names but English, with the two great exceptions of Leblanc and Solvay, do we find in connection with real discoveries? In the application of chemistry to metallurgical processes, too, the names of Darby, Cort, Neilson, and Bell in iron, of Bessemer, Thomas, Gilchrist, and Snelus in steel, of Elkington and Matthey in the noble metals, show that in these branches the discoveries which have revolutionised processes have been made by Englishmen; while Young, the father of paraffin, Spence the alum maker, and Abel of gun cotton fame are some among many of our countrymen whose names may be honourably mentioned as having founded new chemical industries. Hence, while there is much to stimulate us to action in the energy and zeal shown by our Continental brethren in the pursuit both of pure and applied chemistry, there is nothing to lead us to think that the chemistry of the English speaking nations in the next fifty years will be less worthy than that of the past half century of standing side by side with that of her friendly rivals elsewhere.

TELEPHONY IN SOUTH AUSTRALIA.

A VISIT TO THE ADELAIDE EXCHANGE.

[The following special report from *The South Australian Register* will give a good idea of the manner in which telephony is viewed and is progressing in Australia.—ED. *E.*]

A short time ago a London journalist visited the office of the Indo-European Telegraph Company, which occupies an unpretentious building in Old Broad-street, and made an inspection of the wonderful line between England and Teheran, the capital of Persia, the length of which is 3,800 miles. He says that the clerk in charge informed him that he wires through to Emden, and "with the same ease with which one wires from the city to the West End." He asked a few questions of the telegraphist in the German town. When he had finished he spoke with the same facility to the gentleman on duty at Odessa. This did not satisfy him, and in a few seconds he was through to Teheran. From here he passed to Kurrachee, then to Agra, and from Agra he was switched on to another line, and was "soon talking to a native telegraphist at the Indian Government Cable Station, Calcutta." Thus he had, by means of automatic repeaters, communication without break over 7,000 miles of wire, and he attests that the signals were excellent, and that the speed attained was not less than twelve words per minute. This is a most remarkable feat, and one may well ask, where will the achievements of science end? From the Post Office at Adelaide it is as easy to speak Port Darwin as it is to speak Port Adelaide, although the distance in the former case is about 2,000 miles. And, what is more wonderful still, messages have been received from England in less than an hour. On the occasion of the opening of the Melbourne Exhibition a message to the Queen was through from Melbourne to Windsor in forty minutes, and I am informed that in one instance the result of a Derby race reached this colony from England in twenty minutes. If a direct line throughout the whole of the distance were practicable the time would be reduced to as many seconds. The number of messages despatched by these lines has increased with great rapidity. In 1878 the number forwarded by the colonies was 9,283, and the number received by the colonies 8,161, making a total of 17,444 messages, on which were paid £146,125, the South Australian proportion being £16,421. In 1883 the number of messages forwarded from the colonies was 21,771, and the number received by the colonies 21,563, making a total of 43,334 messages, yielding a revenue of £251,278, of which the proportion accruing to South Australia was £27,510. The rate over which messages to Europe travel may not be generally known. The overland line joins the cables at Port Darwin, and the cables cross to Banjoewangie, the southernmost point of Java. The old cable joins a line which goes through Java to Batavia, and from thence the communication is continued to Singapore, Penang, and eventually to Madras, where the ordinary Indian lines are reached. The new cable goes from Banjoewangie to Singapore direct, avoiding Java, where Dutch operators are employed, with results that are sometimes most harassing to the persons who receive the messages at this end. We cannot boast of lines equal to those of the Indo-European Telegraph Company; but our system is one of which we have good reason to be proud. We have made great progress in this respect, and the day may come when we shall be able to go to some exchange of telegraphy or telephony and converse with our friends "at home" with almost as much freedom as if they were speaking to us across our garden fence. When Volta made his discoveries no one anticipated that we should ever flash messages around the world; and when Wheatstone conveyed the sounds of a musical box from a cellar to an upper room by means of what came to be known as the "Enchanted Lyre," it was not even suggested that the time would come when articulate speech would be transmitted over hundreds of miles. We have long since learnt that there are more things in heaven and earth than are dreamt of in our philosophy, and there are few persons who will be disposed to say that science has yet reached its highest point of development. The telegraph and the telephone are among the greatest triumphs of human skill, and both inventions have been applied in South Australia. The principle and mode of operation of the telegraph are well known, but there is a degree of novelty attaching to the telephone, and it is the latter instrument which is to be the special subject of my sketch.

THE INVENTION AND THE IMPROVEMENT OF THE TELEPHONE.

The original of the telephone now in use was discovered by Professor A. Graham Bell in 1877. This consists of a thin disc of iron placed in front of a permanent magnet surrounded by a coil of insulated copper wire. The sound of the voice speaking causes a vibration of the disc, a current of electricity is generated, which being sent round a similar coil on a distant magnet repeats the vibration on another disc, and reproduces the sound. In short, sound is converted into electricity, and electricity is reconverted into sound. This instrument was employed as both a transmitter and a receiver, and it was found by experience that it was not of any practical value for ordinary purposes, inasmuch as the sounds it gave, although distinct, were weak. Something was required to complete the invention, and this something was supplied by Professor H. E. Hughes in what is known as the microphone. This instrument multiplies sound just as the microscope multiplies the field of sight. It consists of two pieces of carbon attached to a diaphragm, which are made to recede from and approach to each other by the vibration caused by the sound of the voice and to offer a variable

resistance to the electric current which is generated. The current passes through a primary wire of a small induction coil, and produces a corresponding current in the secondary wire by which it is enveloped. This secondary, or "induced," current is transmitted through the line, and reproduces the speech in the receiver at the other end. The microphone is now used as the transmitter and the Bell telephone as the receiver, and in addition to these another instrument is required, which may be described as the "call." This may be either magneto-electric or galvanic. In the former the currents are generated by turning a handle, which revolves an armature containing a coil of very fine copper wire between the poles of permanent magnets, and causes alternating currents by which the bells are rung. In the latter a battery, generally of the Leclanché type, is employed; but there are various objections to this system, and the magneto-electric is the one which is most generally adopted.

THE TELEPHONE IN SOUTH AUSTRALIA.

The Postmaster-General (Mr. Todd) and his able assistant in this department (Mr. C. Unbehaun) have devoted close attention to the study of the telephone ever since its invention by Professor Bell. The improvements have been followed, and numerous experiments conducted with the view of ascertaining which was the best of the various systems brought out. In the first instance imitations of the original instrument were constructed from drawings in the scientific journals, and subsequently a variety of different instruments were obtained from England, including the Gower-Bell, which is the system adopted by the postal authorities in England. Mr. Todd eventually selected the Blake transmitter, which is a modification of the microphone, the Bell receiver in the form known as the "Ponycrown," and the "Swiss" telephone. In the year 1880 Mr. Todd submitted a memorandum to the Minister of Education, in which he recommended the Government to establish a Telephone Exchange; and in 1881 a Bill was introduced in the House of Assembly by the Hon. J. L. Parsons for the purpose of giving effect to the scheme Mr. Todd proposed. The Bill gave the Government the exclusive right to erect and maintain telephone lines in the colony, and it rapidly passed through both Houses of the Legislature, the only objection raised to it being based upon what has since proved to be an erroneous assumption that it would interfere with the success of the telegraphic system, and would not contribute anything to the revenue. The Act was first brought into operation in 1882, when a number of private lines were laid down and leased, and the Telephone Exchange was not opened until May of last year. At that time the number of subscribers was only twenty-five, whereas the number at the present time is 263, of which 217 are connected with the Adelaide Exchange and 46 with the Port Adelaide Exchange. In addition to this there are 156 private lines. This is very satisfactory progress, and, considering its age, the exchange will now bear favourable comparison with the exchanges in the other colonies. The number of subscribers in the other colonies at the commencement of this year was as follows:—Melbourne 650, Ballarat 81, Sandhurst 37, Sydney 260, Dunedin 237, Auckland 151, Christchurch 125, and Wellington 60. In addition to the exchanges at Adelaide and Port Adelaide, the telegraph offices at the exchange (Pirie-street), Rundle-street, Adelaide Railway Station, Unley, Norwood, North Adelaide, and Hindmarsh are connected, and the Semaphore and Largs Bay Railway Station are to be added. Branch exchanges are also to be established at the Semaphore and at Mount Lofty, and if the business increases as it has hitherto done further extensions will soon become necessary. There are about 700 sets of telephones now in use, and the greater proportion of these have been purchased for the Western Electric Telegraph Company of Chicago, whose instruments are considered to be superior to those manufactured in England. The total length of wire erected is 983 miles, and the longest telephone lines are the following:—Government House to Marble Hill; 13 miles; M'Culloch—Goolwa to Port Victor, 11 miles; Cave and Co. (S.A.) to Crafers, 10 miles. Mr. Cave joins his Port wire to the Crafers line, and the length is thus increased to 18 miles. The above does not include the railway telephone lines, the longest of which is from Kapunda to North-West Bend, 56 miles, and from Burra to Petersburg, 55 miles. The charges made to subscribers are lower than those imposed by the postal authorities in England, and some special facilities are afforded, some of which do not pertain elsewhere. For instance, Clause 14 of the regulations provides that chemists situated along any existing line of telegraph or telephone within a distance of five miles from a telephone exchange may be connected with such exchange on payment of a subscription of £14 per annum, on the understanding that persons will be allowed to consult any medical subscriber on payment of 6d. for every five minutes, or free of charge where the medical subscriber pays the additional £9 a year. The telephone must be available for purposes of medical consultation day and night; but a private fee of 2s. may be charged during the night, or between the hours of 10 p.m. and 7 a.m. This is a novel arrangement, and the value of it is obvious.

AT THE EXCHANGE.

The system upon which the Exchange is worked is very simple. All the subscribers' lines are brought to a focus at the centre. If a subscriber desires to speak to another subscriber he rings up the exchange, states with whom he wishes to communicate, and is at once connected. To see how things are done I visited the exchange, which occupies what is known as the check room at the General Post Office. I was taken up stairs through a long room in which a host of telegraphists are at work, and into the *sanctum sanctorum*, in which the young lady attendants sit at the telephonic switchboard and answer the calls of subscribers. There were two operators employed in this work, and they were as busy as they could well be replying to the calls and making the necessary connections. The switchboard consists of a series of enunciators with deep shutters, each of which bears the number of a subscriber. Jack-knife switches, corresponding to the enunciators, are placed below; and at the bottom is a row of clearing-out shutters. On the switchboard are two rows of buttons with contact keys, having flexible cords, with plugs attached, which are used for completing the circuit between any two subscribers. When a subscriber rings the shutter of the enunciators with which he is connected drops, and the attendant at once places one of the plugs in the corresponding switch. Having done this, she gives the reply ring by pressing a key, which causes an electric current to pass along the line. The arrangement adopted is a novel one, and, I was informed, is not in use elsewhere. A small turbine, connected with the water service, drives a small magneto-electric machine, which is kept in the crypt in the basement of the building. This supplies the current which rings the bell, and the necessity which before existed of turning a handle, as is done at the subscribers' end, is obviated. The attendant afterwards presses the speaking key, and asks the subscriber with whom he wishes to speak. He replies, and the attendant takes a second plug, and places it in the proper switch, when the connection is complete, and the parties may carry on their conversation in perfect secrecy. When they have finished a signal is given which throws down the clearing-out shutter, and the attendant draws the plugs in readiness for the next call. The whole operation does not occupy more than a few seconds, and the young ladies are able to reply to the requests of subscribers with remarkable rapidity. The number of communications per diem through this exchange is about 1,000, and there is room for almost unlimited extension, the capabilities of the machinery being dependent only on the number of attendants employed. While I was in the exchange many calls were received and answered without a hitch of any kind, and there was nothing to note except that the work was well and efficiently done.

AN IMPORTANT IMPROVEMENT.

After leaving the young ladies in the exchange, I proceeded to the subterranean regions below, some parts of which resemble the cloisters of an ancient Gothic cathedral. After visiting the various apartments, I was taken into the fitting shop, where a number of men were at work repairing instruments, &c. While here we spoke the Port Adelaide Exchange, and my attention was especially directed to the effects of induction. The telephone is its own enemy owing to its sensitiveness. A current passing along one line induces a current in an opposite direction on a neighbouring line, and supposing the telephones to be connected with this latter line they will repeat what is said. Hence a mysterious second voice, or a peculiar pitter-patter caused by the ringing of a bell is sometimes heard when communications are being exchanged. These interruptions interfere with the distinctness of the sounds transmitted, and make the subscriber think that his friend at the other end is amusing himself at his expense by talking double-Dutch. In the ordinary course of things the wire is run to earth, and the earth is used to complete the circuit. For, unless the circuit is complete there can be no transmission of the electric current. Earth is a great conductor, and it is an accepted theory that a current on going to earth will find its way back to the point from which it first came. To overcome the difficulty it has been found necessary to complete the circuit with the line itself, forming what is called a close metallic circuit. The lines are twisted, without being brought into contact, between each four poles, and this has the effect of preventing any repetition of sound. The close metallic circuit is used on all private lines; and a plan has been devised by which it can be adapted to the requirements of the exchange, more particularly in relation to communications between Adelaide and the Port. This plan consists in connecting the subscriber with his own exchange by a single wire, and causing the current to be repeated by induction on the close wire circuit connecting the two exchanges, and again repeated by induction to the subscriber at the other end. This improvement is being introduced, and a new arrangement is in contemplation with regard to the "ringing-off"—a process which, as at present conducted, sometimes leads to confusion.

A NOVEL CLOCK.

While in the fitting-shop I was shown a number of curious instruments and machines, including a "synchronised clock," made by the Standard Diamond Telephone Company (Limited). This clock has a magneto-electric attachment, by which two small figures on the face of the clock are made to clutch precisely at the hour and to regulate the minute-hand. If the clock gains or loses time the hand will at the hour be brought to the centre, and this operation will be continued every hour as long as the clock is going. I understand the system is to be applied at the Post Office. The magneto-electric attachment is to be fixed to the clock in the tower, and this being connected by wire with all the other clocks in the department they will be regulated in the way described.

TRAFFIC RECEIPTS FOR AUGUST, 1884.

Companies.	Aug., 1884.	Aug., 1883.	Increase.	Decrease.
Cuba Submarine	2,375	2,315	60	—
Direct Spanish Telegraph	1,173	1,547	—	374
Eastern Extension	35,967	38,126	—	2,159
Great Northern	—	—	—	—
West Coast of America	—	—	—	—

UNIVERSITY COLLEGE, BRISTOL.

In the Department of Experimental Physics at this College LECTURES and CLASSES arranged progressively are given throughout the Session, and Instruction is given in the Physical and Electrical Laboratory. In the Engineering Department Special Courses have been arranged for Students studying for the profession of Engineering who wish to include in their professional training some knowledge of Electricity and its technical applications, especially with regard to Electric Lighting and Transmission of Power, Telephones and Telephonic Systems, Telegraphy, Electro Plating, &c.

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COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Sept. 3.		Business Done Week Ending Sept. 3. Highest.	Lowest.
Anglo-American	30½,	31½	31	30½
Do. Preferred	54½,	55½	55½	54¾
Do. Deferred	6¾,	7¼	—	—
Brazilian Submarine	10½,	10¾	10¾	10 9-16
Cuba	10¾,	11¼	11	10⅞
Do. Preference	16½,	17½	—	—
Direct Spanish	4½,	5	—	—
Do. Preference	14¼,	15¼	—	—
Direct United States Cable	9⅞,	10⅛	10	9 15-16
Eastern Telegraph	11¼,	11½	11½	11¼
Do. 6 per Cent. Preference	13,	13½	13½	—
Do. 5 per Cent. Debentures, 1899	103,	106	—	—
Eastern Extension	11½,	11¾	11¾	11 9-16
German Union	9¼,	9¾	—	—
Globe Telegraph and Trust	6⅝,	6⅞	6¾	6⅝
Do. Preference	12½,	12¾	12¾	12½
Great Northern	13¼,	13½	13 9-16	13¼
Indo-European	31,	32	—	—
Reuter's	8,	8½	—	—
Submarine	165,	175	163¼	163¾
West India and Panama	⅞,	1⅛	—	—
Do. 1st Preference	7¼,	7¾	7¾	—
Western Brazilian	6½,	6¾	6⅝	6 7-16
Western Union 7 per Cent. 1st Mortgage	123,	125	124¼	123½
Do. 6 per Cent. Sterling Bonds	102,	106	—	—

TELEPHONES.

Companies.	Closing Prices. Sept. 3.		Highest.	Lowest.
Consolid. Telephone and Maintenance	3-16,	5-16	—	—
Oriental	⅛,	⅜	—	—
United Telephone	12½,	12¾	12¾	11 7-16

ELECTRIC LIGHT.

Companies.	Closing Prices. Sept. 3.		Highest.	Lowest.
Anglo-American Brush Light (£7 paid)	1½,	1¾	1 13-16	—
Do. (fully paid)	3,	3½	—	—
Hammond Light (£3 15s. paid)	¼,	½	—	—
Swan	—	—	—	—
Maxim-Weston	1-16,	3-16	—	—

MISCELLANEOUS.

Companies.	Closing Prices. Sept. 3.		Highest.	Lowest.
Telegraph Construction	32½,	33½	33⅜	32⅞
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23 7-16	—

WANTED.—A SITUATION as FIRST LINEMAN, Foreman of Construction Party, or good Assistant to a Mechanic (Telegraphs and Telephones). Experienced abroad. Good references.—Address, U. E., *The Electrician* Office.

AN ELECTRICAL ENGINEER, of good theoretical and practical knowledge, desires an ENGAGEMENT. Would undertake Electric Light or other installation work, or could take management in a small factory. Moderate salary; good references.—"ENERGY," Office of this Paper.

ELECTRICAL ENGINEER, with considerable experience in Electric Lighting, both arc and incandesce t, requires suitable EMPLOYMENT.—Address, E. E., Office of this Paper.

A PRACTICAL ELECTRICIAN, Patentee of valuable Secondary Battery, cheap, light, and of large surface capacity, wishes to negotiate for SALE or WORKING of SAME.—W. W., *The Electrician* Office.

FOR SALE.—PAIR of GOWER-BELL TELEPHONES and TRANSMITTERS; equal to new. Royalty paid. Or would exchange for Dynamo Machine.—Address, WATSON BELL, Guinea Warehouse, Whitehaven.

FOR SALE.—PATENT RIGHTS of VOLTAIC BATTERY, suitable for Motive Power and Electric Lighting. Also Rights of Improvement on Ship Propellers.—Apply to T. and G. B. McKIM, C.A., 149, St. Vincent-street, Glasgow.

DYNAMO MACHINES and ARC LAMPS (Siemens, Bürgin and Gramme) FOR SALE. Stock of company in liquidation. Little used and offered at half price.—MACKAY and MESS, C.A., Dundee.

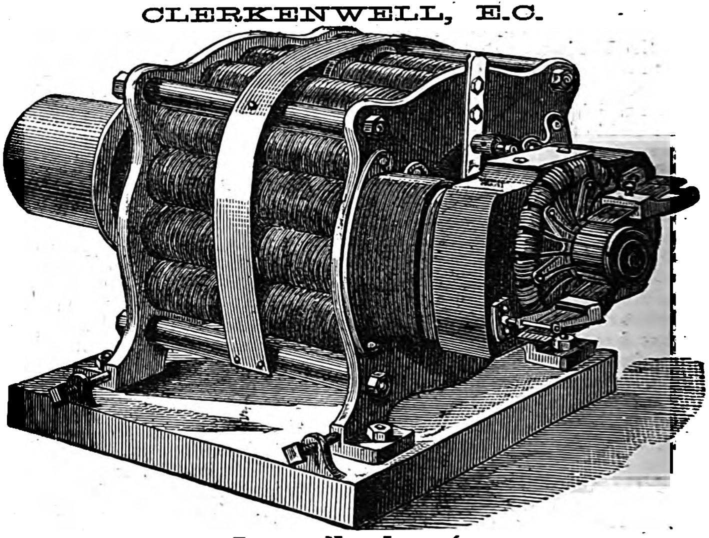
INSULATED ELECTRICAL WIRE, Silk, Cotton, or India Rubber covered. Conductivity guaranteed. German Silver Wires for Resistance. Braided Handle Cord, Silk Cord for Electric Bells, &c.—WILLIAM BICKARD, Derby. London Agent (stock kept), EDWIN HOLLOWAY 2 Gutter-lane E.C.

OPPERMANN BROS.,

Dynamo Machine Makers and Electric Light Engineers.

Works: Brewhouse Yard, 172, St. John Street,

CLERKENWELL, E.C.



TYPE OF NOS. 5 AND 6.

PRICES OF DYNAMOS.

No.	No. of 20-C.P. Lamps.	H.P. Absorbed.	Price.	
1	5	½-H.P.	£10	Shunt or Series-wound Direct Current
2	10	1 ,,	£20	
3	20	2 ,,	£30	
4	50	5 ,,	£45	
5	100	10 ,,	£80	Alternating current; price includes exciter. These machines can be run at full speed, with from one to their full number of lamps in circuit.
6	200	20 ,,	£130	
7	500	50 ,,	£300	

LEGAL NOTICE.—HORRY v. OPPERMANN.

MESSRS. OPPERMANN BROS. have much pleasure in announcing that the plaintiff has formally withdrawn the proceedings instituted against them to restrain alleged infringement of Letters Patent.

THE

SCHOOL OF TELEGRAPHY & ELECTRICAL ENGINEERING.

ESTABLISHED IN 1868.

12, Princes Street, Corner of Hanover Square, London, W.

(Removed from 4, George Street, Hanover Square.)

MANAGING DIRECTOR: MR. T. J. JONES, M.S.T.E.

The course of Practical and Theoretical Instruction in the higher branches of Overland and Submarine Telegraphy embraces in addition to the manipulation of the various systems of wording in general use, the following subjects:—Mathematics, Mechanics, Chemistry in relation to Telegraphy, Gas and other Motors. Signalling and Testing Instruments. Engineering Formulæ and their application in practice. Electro-Statics. Electro-Dynamics. Magnetism. Methods of Testing the Electrical Condition of a Line during and after its Construction. Testing for and Localising Faults, &c., &c., &c. Telephone and Electric Light Apparatus.

The instruction, both in signalling and testing, is of a thoroughly practical character, as the classes work with the actual instruments used on long lines, through cables of various lengths, from 600 to 3,000 knots, so that the signals of the Eastern, Atlantic, and Brazilian Companies, &c., are exactly reproduced, and the pupils fitted for any line.

A complete practical and theoretical course of instruction on the TELEPHONE and the ELECTRIC LIGHT, and their commercial utilisation, has now been added to, and embodied in, the ordinary curriculum, as the advantages of being associated with any great commercial application of science at an early period of its development is one which has been so often exemplified that it can scarcely fail to be appreciated by those who have in view professional success.

That TELEPHONIC communication and ELECTRIC LIGHTING constitute such applications is sufficiently shown by their rapidly increasing progress; and therefore no pains or expense have been spared to place at the disposal of the pupils the technical and scientific nstruction requisite to qualify candidates for the most important posts in connection with these new branches of electrical engineering. In order that the instruction in the erection, adjustment, testing, and working of TELEPHONE and ELECTRIC LIGHT circuits may also be thoroughly practical, complete working telephone exchanges upon the various systems in use in different countries have been fitted up; every kind of telephone, for both exchange systems and private lines, with all apparatus used therewith, is provided (in duplicate when possible, so that students may be able to dissect and reconstruct the same). The necessary tools and materials are available, and every facility is given for conducting experiments by the pupils desirous of so doing, and a similar course has been pursued with the VARIOUS LAMPS and MACHINES, &c., in the ELECTRIC LIGHT Department, so that Pupils from the School are in a position to enter either of these new fields. Civil and mechanical engineers, sons of professional gentlemen, and others, will now have an opportunity of acquiring a knowledge of all the telegraphic systems of working, of the construction and management of land and submarine telegraphs, of telephone lines, systems and exchange, of the construction, erection, and management of electric light apparatus, testing wires, lines and materials employed, submarine cable testing, localising faults, &c., &c.

Arrangements have been made so that Inventors, Amateurs, and others can now have every facility, with all necessary apparatus provided in private rooms, to compare, test, or perfect any Inventions, Apparatus, &c., connected with Telegraphy, Telephony, and the Electric Light. The highest professional assistance can also be had.

Further particulars may be obtained on application to W. N. TIDDY, *Secretary*.

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NOTES.

SAMARCAND.—The telegraph line between Samarcand and Bokhara was opened on September 9th.

ELECTRIC LIGHT AT NAPLES.—It is decided to light by electricity the underground railway to be made in Naples.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of August amounted to £26,800.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ending Aug. 31st were £3,690.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 29th August amounted to £3,251.

KRUPP'S WORKS.—At these well-known works, there are in use some 40 miles of telegraph line, joining 35 stations for the working of 55 Morse instruments.

ELECTRIC LIGHT AT MAYENCE.—Siemens and Halske, of Berlin, have instructions to put up twenty-seven 800-candle arc lamps at the Central Station, Mayence.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of August amounted to £45,329, and to £44,937 in the corresponding period of 1883.

ELECTRIC LIGHT AT LEIPSIG.—The gas company of this town has received a concession from the municipality for a central station to generate electricity for both lighting and power.

ANTWERP EXHIBITION.—The Belgian Government has reduced by 30 fr. per square metre the rent of space, which was originally fixed at 70 fr., so that the actual cost is now 32s. for 10¾ square feet.

ELECTRIC LIGHT FOR LIGHTHOUSES.—A lighthouse, illuminated by electricity, in the Island of Clippy, is approaching completion. Its flashing red light is expected to be visible for a distance of 15 miles.

PARIS EXHIBITION OF 1889.—There is a movement on foot for securing the erection of this exhibition, which seems to be definitely decided upon, in the neighbourhood of Vincennes instead of Boulogne-sur-Seine.

EDISON'S NEW SHIP LIGHTING MACHINE.—This machine we are informed is a great improvement upon earlier types. It gives current for 300 16 candle-power lamps at 110 volts with only 300 revolutions per minute.

THE PHILADELPHIA EXHIBITION.—We understand that Mr. Killingworth Hedges has been invited to act as a member of the Board of Examiners of the Philadelphia Exhibition, of which Prof. M. B. Snyder is chairman.

ROYAL COLLEGE OF SCIENCE, DUBLIN.—The winter session of this college commences on October 4th. There will be a special course of Applied Electricity and Laboratory Work, under the direction of Professor Barrett.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 5th inst. were £2,450, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

ELECTRIC LIGHT AT BERLIN.—The central station for the electrical illumination is nearly finished; it will contain four Edison 500-lamp dynamos, with the steam engines and boilers for driving them, capable of maintaining 2,000 16-candle incandescent lamps.

THE TELEPHONE IN THE FRENCH BLACK COUNTRY.—The Lyons journals report that an engineer of the *Société Générale des Téléphones* has lately visited the metallurgical centres of Saint-Etienne, Saint-Chamond, and Rive-de-Gier, with a view to putting them in telephonic communication.

AMBULANCE ELECTRIC LIGHT.—As a result of the recent experiments with the electric light for aiding the search for dead and wounded on the battle field, the Geneva Conference has decided to recommend European Governments to adopt this light in future as part of the ambulance plant.

ELECTRIC LIGHT AT NEW YORK.—It is now proposed to place an automatic electric lamp in the torch of Bartholdi's colossal statue of Liberty Enlightening the World, in New York roads. A current of 60 amperes, with an E.M.F. of 70 volts, will be required for the lamp; and a Mangin reflector will throw the light a distance of 60 miles.

ELECTRIC LIGHT IN THEATRES.—The Ambigu Theatre, Paris, is now added to the gradually lengthening list of theatres illuminated by electricity. The light was used for the first time on the 6th inst., being supplied by the Société d' Eclairage Electrique, the only company that has (says the *Bulletin*) succeeded in completely superseding gas in a Paris theatre.

ELECTRIC HEAD-LIGHT FOR LOCOMOTIVES.—Three companies have been formed in America for working a patent, obtained by Mr. Wooley, for a new head-lamp maintained by a dynamo worked direct by a separate motor, which receives its steam from the locomotive boiler. It appears that the trials on the Chicago, St. Louis, and Pittsburg railway are regarded as satisfactory.

FOOCHOW.—The Great Northern Telegraph Company notify that the steam launch service between Sharp Peak and Foochow having been forcibly interrupted by the Chinese military authorities, telegrams for Foochow can only be accepted for transmission by the Chinese Government land lines from Shanghai, and they must be written in plain English, the use of code words being forbidden.

CHINA.—The Eastern Telegraph Company notifies that, from 1st September until further notice, telegrams for all places in China, with the exception of Shanghai, Amoy, Hong Kong, and Macao, must be written in plain English language. The company also notifies the restoration of the Chinese Government land lines to Tientsin, but owing to pressure of work telegrams will be subject to some delay.

HATCHETT'S HOTEL, PICCADILLY.—Messrs. B. Verity and Sons have fitted this hotel with the electric light. The installation consists of 130 Edison lamps supplied by two of the new 100 light dynamos which are driven by Otto gas engines. Two engines of 12 horse-power each are put down, either of which will supply all the power required. The work has been excellently done by Messrs. Verity and Sons.

ELECTROMOTIVE TRAMCARS IN BRUSSELS.—The working, by electromotive tramcars or electro-locomotives, of the tramway along the Rue de la Loi, Brussels, which should, according to contract made between the Tramway Company and La Société Belge et Hollandaise d'Electricité, have been commenced on 1st July, has been postponed on account of successive improvements introduced into the electrical portion of the vehicles.

THE TELEPHONE IN THE NORTH OF FRANCE.—The journals of this district report that the *Société Générale des Téléphones* has ceded to the French Government the telephone system

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that they laid down in Lille five years ago. It appears that the inhabitants object to this arrangement, as they fear they will not be so well served by Government management. They even threaten to boycott the telephone if their claims are not attended to.

A YOUNG LADY KILLED BY LIGHTNING.—During a thunderstorm in Orkney, Miss Wilhelmina Leask, residing with her mother at Knockhall, near Stromness, was killed by lightning. Along with some friends, the deceased had been in the harvest field, and when the storm came on they separated. Shortly afterwards, the young woman was found lying on her face quite dead. The lightning struck her on the neck, tearing and burning her clothes, breaking a watch in her pocket, and tearing the boots from her feet.

THE NEW ATLANTIC CABLE.—The cable steamer "Faraday" has arrived at Messrs. Siemens's telegraph works, Charlton, after having successfully laid the first portion of the second Bennet-Mackay Atlantic cable, and is now engaged in taking on board the second portion. It is hoped that both cables will be in working order by the 1st of October. Dr. Muirhead is engaged in duplicating the cable already laid. The work on this side has been done, and Dr. Muirhead is now gone to America to complete the work there.

EGYPT.—It is said to have been decided to erect a light land line by the banks of the Nile for the purposes of the forthcoming expedition. Though the arrangements are not wholly complete, the military authorities contemplate utilising the services of some of the non-commissioned officers and men of the 24th Middlesex Volunteers (Post Office) belonging to the telegraph companies. These men are all skilled manipulators, some of whom have served in Egypt before. The men will be attached to the Royal Engineers, whose scarlet uniform will take the place of the dark grey of the volunteers.

A NON-MAGNETISABLE WATCH.—The editor of the *Centralblat für Electrotecknik* informs his readers that he has got a keyless watch, made by a Nuremburg watchmaker, which is uninfluenced by the electric current. It has gone well for a whole year, although placed near one of the poles of a powerful electro-magnet. We should be glad of details of this useful watch, the possession of one such being better than any of the alternatives supposed to be the only resource with a magnetised watch, viz., subjecting it to alternate currents of decreasing intensity, raising it to a red heat, or throwing it on the scrap heap.

ELECTRIC LIGHT IN THE FURNESS DISTRICT.—Ireleth and Askam are outlying villages within the district of the Dalton Local Board, in that rich iron-bearing promontory known as Furness, in North Lancashire. They are far from gasworks, and laying pipes would be a costly matter. Here, then, is a capital field for the introduction of electric light, especially as the neighbouring Roanhead mines are now lighted on the arc system. The Board has decided, we think unwisely, to adopt the incandescent system, with Menzies' lamps, for the two villages above named, and we look forward with interest to the result of the experiment.

COMPETITION IN TELEPHONES.—The Trinidad papers announce that Mr. Gray, the manager of the American Telephone Exchange in Port of Spain, has been recently superseded by another gentleman, sent out by the parent company in New York. Subsequently Mr. Gray submitted to the mercantile community of Port of Spain a proposal to form a new telephone company with lower rates than the present one, and bound himself to have everything ready to start in January next. Most of the leading merchants present agreed to the proposal, and signed a preliminary arrangement. So it would seem the "grey" mare proved to be the better horse.

COMPARISON OF COST.—The cost of electric light for illumination, as compared with gas, has been computed by Hartford, Conn., where arc lights have been in use for about a year. The report states that each electric light in use displaces six and a half street burners, besides giving at the same time at least ten times as much light. The gas lamp costs 35dols. per burner per annum, kept burning 328 nights in the year, while for the electric lights 65 cents. a night is paid. The electric light being equal to six and a half gas burners, a saving of 15·60dols. per lamp per year is effected by the use of electricity, besides the cost of lighting and extinguishing the gas lamps.

FRENCH SUBMARINE CABLES.—*L'Electricité* gives the following list of submarine cables laid in France since 1878 by the French Minister of Posts and Telegraphs, forming, with the subsidiary submarine communications for completing the coast lines, an increased length of 3,210 kilometres (1,990 miles), or an average of 535 kilometres (330 miles) of new cable yearly:—In 1878, a direct line between France and Corsica; in 1879 and 1880 two new cables between Marseilles and Algiers; in 1881, a cable between La Calle in Algeria and Bizerte in Tunis; in 1882, one between the last-named place and Bône in Algeria; and a series of cables on the east coast of Tunis, between Soussa, Sfax, Gabes, Djebba, and Zarzis.

BICHROMATE OF POTASH.—M. Roemer has found a process for the economical production of bichromate of potash, which consists in melting together 100 parts of chrome ore with 150 parts of potash and 30 parts of soda. The levigation is effected, as usual, with water; and the resulting liquor, which contains chromate of potash and chromate of soda, is treated with sulphuric or hydrochloric acid in suitable proportion to form bichromate of potash and sulphate of soda. By evaporation the bichromate of potash becomes crystallised. An equivalent of neutral bichromate of potash, with an equivalent of neutral chromate of soda, require an equivalent of monohydrated sulphuric acid, and yield an equivalent of bichromate of potash, an equivalent of sulphate of soda, and two equivalents of water.

A DELICATE QUESTION.—The householders at Dundee are in a state of uncertainty with regard to the question how to treat the rent derived from telephone wires. At a meeting the other day of the Finance and Police Committees of the Dundee Police Commission, the question was raised whether house proprietors included in their returns to the Assessor of Taxes the amount received by them as rent for the erection of telephone wires and standards on their properties. Several members said that such payments must be regarded as rent, and that the rental of the burgh would be increased by several hundred pounds if the money paid to house proprietors by the telephone companies was included in the valuation roll. The meeting instructed the treasurer to communicate with the assessor on the subject.

IMPROVED EARTH CONNECTION.—Herr J. Halitz, chief electrician of the Galician railways, has devised a new arrangement of metal plates intended to ensure the earth connection of the ends of telegraph lines. A layer of medium-sized coke is placed in a hole, two metres deep, and having a square metre (10¾ square feet) of surface. On this coke rests a wooden pipe, 38 square centimetres, or nearly six square inches, in sectional

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area, filled with coke, and surrounded by earth. On the top of this pipe is a block of coke, previously immersed in melted lead; and this block is itself fixed to a copper rod which communicates with the telegraph line. This arrangement permits any gas which may issue from the earth to pass off freely into the air, and thus is counteracted the resistance offered by the gaseous layer which is sometimes formed on the surface of earth plates.

THE EARTH'S MAGNETISM.—The six subterranean chambers at the Paris Observatory, for securing a uniform temperature, in order to study the earth's magnetism, have just been completed. The internal dimensions of each are 60 metres by 16 metres; and the walls, of concrete and millstone grit, are 1·8 metre, or 6ft., thick. Inside the space thus formed come the inner chambers, isolated from the outer by a gallery 2 metres wide, the inner walls, of similar construction to the outer, by 80 centimetres, or nearly 3ft., thick. The height of the chambers is 3·65 metres = 12ft. under the crown of the arch, which is a metre thick, covered with earth to the depth of 2 metres, turfed and planted with shrubs. The observation chambers are destined to receive the following instruments:—Recording apparatus of magnetic variations; Lamont's instruments for direct observation; and Arago's appliances. Strange to say, gas has been adopted for illumination.

TELETHERMOMETER FOR THE BRUSSELS OPERA HOUSE.—A thermometer has been devised for the Théâtre Royal de la Monnaie, Brussels, for recording in a central office the various degrees of temperature at different points of the house. It consists of thermometers placed in any parts of the building the temperature of which it is desirable to be constantly informed of; of a receiver in the central office, indicating the temperatures; and of an electric battery. The action is due to a spiral spring, like that of a Bourdon pressure gauge, expanding and thus closing an electric circuit, by means of which the indication is given, eight Leclanché cells affording the current. The expansion and contraction of the spiral spring cause an indicator hand to move along a graduated arc; and the point, as it reaches the successive degrees, closes corresponding circuits which communicate with the receiver. The first idea of the instrument is due to M. Bordiau, architect, who got out the arrangements for warming and ventilation; and it is made by M. Emile Closset, electrical engineer, Brussels.

NEW CABLE BETWEEN SENEGAL AND THE CANARIES.—The *Bulletin Mensuel des Postes et Télégraphes* has just published the text of two conventions concluded by France, one with the Spanish National Submarine Telegraph Company, and the other with Spain, settling the conditions of the laying and working of the submarine cable for connecting Senegal with the Canary Isles, and communicating with that already laid between the Canaries and Cadiz. The concession is for 25 years, after which the cable is to become the property of the French Government, who grant the company a subvention of 1,700,000fr. (£68,000), payable by instalments. After the fifth year of working the Government has the option of buying up the rights of the company. The cable will be subject to the provisions of the international convention, the official messages of the Government being transmitted at half rates. The receipts are to be shared by the French Government and the company in the proportion of one-third for the former and two-thirds for the latter, after deducting 10 centimes (1d.) for the transit tax due to the Spanish Government.

THE WRONG ORDER.—Once a year great amusement is obtained from the Postmaster-General's report, in which it is stated that letters are posted without addresses, and addresses without letters, and so on, and our comic papers and our novelists can always utilise the idea of the change of letters into the wrong envelopes. A laughable case has just occurred in which the wrong letter has evidently been sent to Messrs. Crompton and Co., the well known manufacturers of dynamos:

"High-street, ——

"Dear Sir:

Please send to —— Station, Great Eastern Rail,

3 pair each women's elastic side boots,
3-4-5-6 size, 4s. 6d.
2 pair each women's Memal top, button,
4-5-6 size, 5s. 6d.; or
2 pair each women's kid top, button,
3-4-5 size, 6s.,

And oblige

Yours, &c.,

——."

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The following has been issued by the Secretary of the Institute:—Inquiries have been made as to the present standing of enrolled members. According to rules, certain qualifications are necessary for both members and associate members. The Council has defined the rules by resolution as follows:—Qualifications for a member: "He shall have practised on his own account, or in the service of some individual, organised institution, or company engaged in electrical work, in the capacity of electrical engineer, or electrician, for at least two years; or he shall be so intimately associated with the science of electricity, or the progress of the art, that the Council consider his admission to membership would conduce to the interests of the institute." Qualifications for an associate member: "Any person of good standing in the community, properly endorsed, who is in any way interested in electrical matters or studies." At present all enrolled members, of whom there are nearly three hundred, stand upon the same footing—that of associate members. Those now enrolled, who possess the necessary qualifications, and who desire to become members, may do so by applying to the Council for its action on the matter, as provided by the rules. The proper blanks will be furnished by the secretary.—*Electrical World.*

THE BRITISH ASSOCIATION IN 1854.—It has been our custom to compare notes of the current meeting with that of twenty years ago. The period is not a long one, but comparison always brings sadness in that we recognise how many able workers and earnest supporters of the Association have passed from among us. In 1854 the meeting was held at Liverpool, in the month of September. Among the names of those who submitted reports we miss at our meetings now Mallet, Chesney, Powell, Sabine, Rosse, Daubeny, &c. The purely electrical papers at this meeting were of a very insignificant character, scientifically considered, though historically Mr. J. W. Brett advanced the claims of himself and his brother, Mr. Jacob Brett, to the invention and perfection of submarine telegraphs. Mr. E. B. Bright read a paper on "Magneto-Electricity and Underground Wires;" Sir John Ross one on the "Deviation of the Magnetic Needle" peculiar to Liverpool; Mr. Archibald Smith on a "Graphic Method of Correcting the Deviations of a Ship's Compass;" Prof. W. Thomson (now Sir W. Thomson) discussed "Experiments in Thermo-Electricity;" Professor Tyndall discoursed on "The Diamagnetic Force;" Mr. C. F. Varley on "Improvements in Submarine and Subterranean Telegraphy;" and Captain Ward on "The Application of Voltaic Electricity to the Firing of Gunpowder."

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MECHANICAL DEPOLARISATION OF BATTERIES.—Under this head, M. V. Bablon makes a few judicious reflections in our contemporary, *L'Electricien.* Although, when great intensity is required, an electrical generator of some type or other would naturally be preferred to a battery, still there are occasions where special circumstances may render the use of large batteries advisable. In such a case some mechanical means for depolarising the positive electrode may be adopted with advantage, as the circular form of plate revolving in the liquid is inconvenient. The writer advises that the positive electrode consist of a supple metallic band passing over two rollers, the lower immersed in the liquid, and the upper caused to revolve. The portion of band not immersed in the liquid is of sufficient area for each successive point to become completely depolarised by contact with the air before being again immersed. The effect may also be increased by means of brushes rubbing against the band, and causing the liquid drawn up with it to fall down more quickly, thus effecting a more perfect contact of the surface with the oxygen of the air. The zinc pole is placed between the two sides, ascending and descending, of the positive electrode; and two other zincs may also be placed opposite the two other faces of the band, so as to increase as much as possible the active surface of the battery. The direction of the band, both in the liquid and out of it, may be varied according to the arrangement of the battery.

ELECTRIC LIGHTING AT BRIGHTON.—An offer has been made to the Corporation of Brighton by the Hammond Electric Light Company, and was laid before the Town Council this week, with the view of putting into operation the provisional order obtained by the Corporation for the lighting of a district including part of the King's-road and the centre of the town. It was calculated that the expense would amount to something like £60,000, and when the matter came before the Council they decided to let it rest for six months pending further improvements or more definite knowledge of house-to-house lighting. The result has not been considered satisfactory, and the committee with whom the matter was left have not stirred in it, though the Council have, on the other hand, laid down a system of electric lighting at the Royal Pavilion, where both in the rooms and in the grounds on the occasion of outdoor fêtes in the evening it has proved effective. Otherwise the supply of electricity for illuminating purposes in the town generally has been left to the Hammond Company, who have a station at an iron foundry near the railway. The company now propose to take over the powers of the Corporation under their provisional order, which they suggest should be varied so as to abolish the area of compulsory supply, leaving them to supply electricity only where it could be done at a profit, to nearly double the maximum price, and to make other considerable variations, regarding which they expressed the opinion that the Board of Trade would be happy to vary the terms of the order, so that one Corporation in England at least should put into force in a modified form the provisional order of the Electric Lighting Act, 1882, "which unfortunately and to their great disappointment has up to the present been practically a dead letter." As to the profits, the company proposed that the first 10 per cent. should go to them, and any surplus be divided between them and the Corporation, the latter having power to purchase the undertaking at six months' notice. The committee, however, do not consider it would be advantageous to the town to agree to the offer and consequently recommended the Council to refuse it.

MUSIC BY TELEPHONE.—The transmitting by telephone of musical sounds, and even a whole concert or operatic performance, is no longer new; but intelligence reaches us from Brussels of a novel phase of this combination in connection with the long-distance telephoning along telegraph wires by the Van Rysselberghe system. The Committee of the Antwerp International Exhibition, to be held next year, and in which electricity will take a prominent part, are providing an additional attraction—magnetic it turns out to be as well as in the showman's sense—in a concert room, where visitors may hear music from Brussels, and other places, transmitted by telephone through the existing telegraph wires. A trial—not rehearsal—of the arrangements was made a few days ago, and we are informed surpassed the most sanguine expectations. The orchestra of the Brussels Opera, playing in the Wauxhall concert kiosque of the Parc at Brussels, was distinctly heard at Antwerp, a distance of about thirty miles. And, not only was the orchestral performance distinctly reproduced, but a violin solo, Gounod's "Meditation," was heard in its minutest details, although the ordinary telegraph service was not suspended. Six microphones had been fixed to two small columns of the Wauxhall orchestra, on a level with the musical instruments; and carbon transmitters, of the model devised by M. Van Rysselberghe, mounted in quantity and actuated by a small Faure accumulator, were put in connection with the central office of the Compagnie des Téléphones. From this spot the circuit was continued by a double wire, so as to avoid telephonic induction, as far as the directors' office of the Central Telegraph Station at the Northern Terminus, Brussels. Here ten Bell receivers were intercalated in the circuit, so as to allow of the music being heard (while being transmitted to Antwerp) by the Minister of Railways, Posts, and Telegraphs, and the principal officials of the Government Telegraph Department, who warmly congratulated M. Van Rysselberghe on this additional application of his invention. At Antwerp were assembled Professor Rousseau, President of the Electrical Committee of the Antwerp Exhibition, some members of the Commission, several directors of the Bell Telephone Company, Lieutenant Lemière, of the Military Telegraphic Department, Antwerp; M. Charles Mourlon, manager of the works where M. Van Rysselberghe's apparatus is made, and M. Berlin, superintendent of the arrangements for adapting the Belgian telegraph wires for telephoning, under whose direction this interesting trial took place.

DEATH FROM INTENSE CURRENTS.—In conjunction with Professor Brouardel, M. C.-M. Gariel has drawn up a report (reproduced in full by *L'Eléctricien*) on the circumstances attending the death of two young men, Martin and Kenarec, through contact with the conductors for furnishing the current to electric lights at the *Fête de la Presse*, held recently in Paris. On leaping the ha-ha, which separates the Tuileries Gardens from the reserved portion, they became entangled in the wires. A Garde de Paris, who noticed the incident, but did not see them re-appear, went to the spot and found them lying at the bottom of the trench, one dead and the other dying. Although the sloping side of the trench had not been watered on the day of the accident, it could not have been quite dry, owing to the rainy weather. There were two conducting wires extending from a raised frame in the central alley of the Tuileries Gardens to a tree, where they were attached by insulators, and then continuing to another post. The wires, covered with insulating material, descended to the ground, and were then laid horizontally along the face of the wall, under the coping, being held in place by small cords attached at intervals to the iron balustrade surmounting the wall. At the spot where the accident occurred one of the wires was insulated for its whole length; but the other was uncovered

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for a portion of its length, being held by porcelain insulators attached by iron wires. This wire was stretched so tightly that it could not be made to touch any metal near which it passed. One of the unfortunate young men must have fallen and so touched the naked wire, while the other is supposed to have seized it in order to draw himself up the perpendicular wall. In the circuit were twelve Siemens arc lamps, maintained by an alternate-current machine placed in the Court of the Tuileries. Therefore the mean difference (although constantly varying from the maximum to the minimum) between the potential of the two wires must have been about 500 volts, while the difference of tension may be put approximately at 250 volts. After examining several hypotheses as to the manner in which the fatal accident occurred, M. Gariel concludes that death ensued, in both cases, through the passage of a portion of the current through the body, which came in contact with the naked wire at two different points, and thus formed a shunt circuit. Although the portion of current thus passing through the body can only have been a slight fraction of the whole—because the resistance of the human body is enormous compared with that of a 6mm., say ¼in., copper wire, of the slight length represented by the distance between the two points where contact was established—it is far from being proved that the intensity, that is to say the quantity, of the current is a measure of the effect produced. Perhaps, suggests the writer, it is the energy which determines the intensity of the action—that is to say, the product of the quantity of electricity by the fall of the potential. And he believes that the electricity operated indirectly by suspending the action of the nervous system, and thus bringing about a fatal result, because there was no material injury caused by the electricity capable of directly causing death. Professor Brouardel is of opinion that death was instantaneous in the case of Martin, the immediate cause being cessation of the heart's action; and Dr. Bourrot concluded, from a detailed examination, that stoppage of the heart's action, though not so sudden, was also the immediate cause of Kenarec's decease. In the installation generally all the wires were covered, except those placed above the reach of the public, who were excluded by a wire fence from the ha-ha, in which were laid the two conductors, one covered and the other uncovered.

Influence of Heat and Magnetism on the Electrical Resistance of Bismuth.—In a paper on the above subject, by M. A. Righi, published by the *Journal de Physique*, the author, after giving an account of his experiments, arrives at the following conclusions:—"1. The resistance of the bismuth of commerce increases on its being heated between certain temperatures, and dimishes between others. As a rule, the resistance diminishes at temperatures near the ordinary temperature. In constructing the curve of resistance, with the temperatures as abscissæ and the specific resistances as ordinates, a curve in the form of the letter M is generally obtained. There is a maximum at a low temperature, then a minimum, then a second maximum a little before the temperature of fusion is reached, and lastly a second minimum after the changes of condition. When the metal is liquid, its resistance increases regularly with the temperature. 2. The diminution of resistance during fusion (that is to say, its passage from the second maximum to the second minimum), reduces the resistance by almost one-half. 3. The temperatures of the two maximums and of the first minimum vary with the conditions of solidification and cooling of the bismuth. 4. If bars of bismuth be taken, the temperature of which, after fusion, has sunk with progressive rapidity, it will be observed that the two maximums approach one another, the temperature of the first increasing and that of the second diminishing. The first minimum, comprised between the two maximums, gradually disappears; and the resistance curve shows two deflections in its place. Lastly, with a still more rapid cooling, the deflections disappear; the two maximums become merged in one, and the curve of resistance begins to resemble a parabola. The variations of resistance then present only two phases, the first of increased resistance commensurate with the temperature, and the second of diminution, which continues until fusion ensues. For instance, bismuth, when cooled slowly, has shown the first maximum at −40° Cent., the first minimum at 115° Cent., and the second maximum at about 240° Cent. Bismuth cooled very rapidly has given a single maximum at about 50° Cent. To these changes in the resistance curve corresponds a variation of physical characteristics similar to those connected with the hardening and tempering of steel. Moreover, hardened wires melt at a temperature a few degrees above that for annealed wires. 5. Wires obtained by pressure, hot, show curves of the same forms, but higher. 6. In the case of wires obtained by pressure, cold, similar but still higher curves are obtained. 7. The resistance offered by the bismuth of commerce varies, therefore, not only with the temperature, but also with the manner in which the piece is prepared and with the temper (degree of hardness). Thus, the resistance of 0° C., by comparison with mercury, has varied, according to the degree of temper, from 2·4 to 3·5 for the metal when cast, from 3·3 to 4·2 in the case of wires obtained by pressure, at a temperature near that of fusion, and from 3·9 to 6·3 in the case of wires made by pressure, cold. For the metal in a state of fusion, 1·3 has been observed. 8. Bismuth chemically pure behaves like the other metals; it cannot be hardened to any appreciable extent; and its resistance at zero Centigrade has been found to be 1·15. 9. The difference between pure bismuth and that of commerce depends upon the traces of tin which communicate to it properties similar to those owing to which steel differs from iron. 10. By adding to bismuth tin in gradually increasing quantity, the specific resistance increases considerably until the maximum is attained, and then diminishes rapidly. The resistance at zero Centigrade for bismuth, which contains 0·1, 0·23, 0·56, 2, and 10 per cent. of tin, has been found to be respectively:—2·47, 3·47, 4·24, 3·65, and 1·84. These values correspond to the metal cooled slowly. 11. The presence of tin in gradually increasing quantity modifies the resistance curve, in the same manner as a gradually increasing degree of hardness. 12. The resistance of bismuth, whether pure or not, increases when it is placed in a magnetic field. 13. This increase of resistance takes place either when the bar or band traversed by the current in the direction of its length is placed in the direction of the lines of magnetic force, or when it cuts them at right angles; but in the latter case it is much stronger. In the author's experiments the increase of resistance has attained one-eighth of its value. 14. Hardened bismuth is less influenced by magnetism than that unhardened, in so far that the ratio between the variation of resistance and the initial resistance is smaller. In the same way, compressed bismuth is less affected than that which has been cast, and the bismuth of commerce a little less than the pure metal. 15. The variation of resistance is proportional to the magnetic force, except for slight values, for in that case it increases a little more rapidly than the intensity of the magnetic field. 16. The variations of resistance due to magnetism diminish on raising the temperature of the bismuth, at least up to about 100° C.; but M. Righi has not continued his experiments in this direction to higher temperatures.

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AN EXTRAORDINARY EXPERIMENT IN SYNCHRONOUS-MULTIPLEX TELEGRAPHY.*

BY PROFESSOR EDWIN J. HOUSTON.

A most extraordinary experiment, which is not devoid of practical bearings, has quite recently been made by Mr. Patrick B. Delany with his synchronous-multiplex telegraphic system, which is now in operation between Boston and Providence, a distance of about fifty miles.

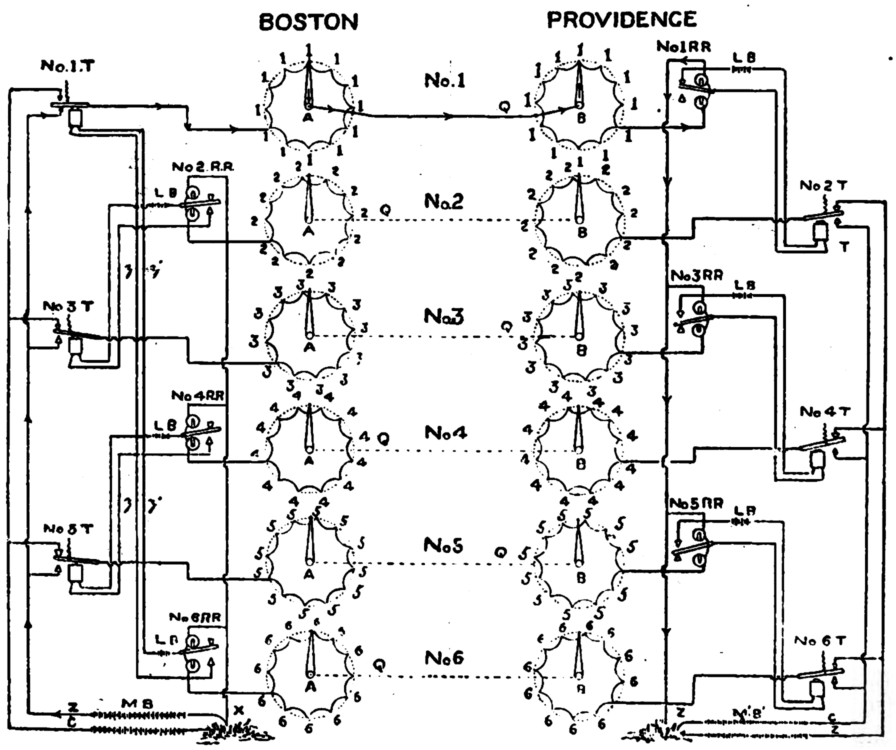
As the experiment about to be described almost challenges belief in its possibility, I desire to state that I have seen it myself, and can vouch for the accuracy of the facts herein stated.

Wishing to try the adaptability to the synchronous system of the automatic repeaters employed by other telegraphic systems, whereby great distances are overcome, Mr. Delany, on three different occasions during the past two weeks, successfully employed such repeaters with his system, the last trial, viz., that on Monday, the 14th of July, being witnessed by myself.

One of the two wires erected by the Multiplex Company between Boston and Providence was divided into six separate and distinct Morse circuits. The first of these circuits, which we will call No. 1, was operated to Providence, at which place the receiving relay on that circuit was connected to the transmitting instrument on No. 2 circuit. In Boston the receiving relay of No. 2 circuit was connected to the transmitting instrument of No. 3 circuit. In Providence the receiving relay of No. 3 circuit was connected to the transmitting instrument of No. 4 circuit. In Boston the receiving instrument of No. 4 circuit was connected to the transmitting instrument of No. 5 circuit. Finally, in Providence the receiving relay or instrument of No. 5 circuit was connected to the transmitting instrument of No. 6 circuit. Under these arrangements, the transmitting instruments at both stations were operated by the receiving relays on the other circuit the same as if worked or operated by an operator; in other words, the six separate and distinct circuits established by the synchronising apparatus between Boston and Providence were arranged so as to form in reality a continuous wire stretched six times between Boston and Providence, with both of its free ends in Boston.

Mr. Delany then transmitted a message on the No. 1 circuit, from Boston to Providence, which was automatically retransmitted from Providence to Boston on No. 2 circuit; again automatically retransmitted from Boston to Providence on No. 3 circuit; again automatically retransmitted from Providence to Boston on No. 4 circuit; again automatically retransmitted from Boston to Providence on No. 5 circuit; and finally automatically transmitted from Providence to Boston on No. 6 circuit. Or, in other words, the message sent from Boston on the first circuit went to Providence, came back to Boston, again went to Providence and came back to Boston, when it again went to Providence and came back to Boston, at which final station it was clearly read by an operator without the loss of a single character, or the slightest impairing of its original clearness, and without the aid of any person except the transmitting operator on the No. 1 circuit in Boston and the receiving operator on the No. 6 circuit in Boston. All this was done over one and the same wire, so that the message travelled in its back and forth journeys between the two cities about three hundred miles, or six times the distance between the two cities.

A reference to the drawing will render the preceding explanation clearer. The synchronised distributing instruments A and B, situated at Boston and Providence respectively, are connected by the single main line Q Q. The line is divided into six circuits, which we will call respectively No. 1, 2, 3, 4, 5, and 6. For the purpose of rendering the connections clearer, these six circuits have been separately represented with the sychronised distributing instruments connected therewith. It will of course be understood that but a single main line, Q Q, furnished with but two distributing instruments, viz., one, A, at Boston, and the other, B, at Providence, exists between the two cities.



This being premised, an inspection of the drawing will show that the main battery, M B, at Boston, split and grounded at X, is connected with the No. 1, No. 3, and No. 5 transmitters, which are respectively connected with the No. 1, No. 3, and No. 5 sextuplex circuits of the single main line Q Q. At Providence the main battery M[1] B[1], split and grounded at Z, is connected with the No. 2, No. 4, and No. 6 transmitters, which are respectively connected with the No. 2, No. 4, and No. 6 sextuplex circuits of the single main line Q Q.

At Providence, the No. 1 receiver is connected with the transmitter of No. 2 circuit, so that a message sent from Boston by No. 1 transmitter would be received by the No. 1 receiving relay in Providence, which, by means of the local battery L B, would have its message repeated by No. 2 trans-

* From the *Journal* of the Franklin Institute for September, 1884.

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mitter, and sent to Boston over the No. 2 sextuplex circuit of the main line Q Q. This message would be received in Boston by the No. 2 receiving relay, which by means of the local battery L B, connected with No. 2 receiving relay, would have its message automatically repeated by the No. 3 transmitting instrument at Boston, over the No. 3 sextuplex circuit of the main line circuit Q Q, to Providence, at which place it would be received by the No. 3 receiving relay. This relay, in its turn, through the aid of the local battery connected with it, automatically transmits the message through the No. 4 transmitter, over the No. 4 sextuplex circuit of the main line Q Q, to Boston, at which place it is received by the No. 4 receiving relay. This relay, in its turn, through the local battery L B, connected therewith, automatically repeats the message to the No. 5 transmitting instrument, over the No. 5 sextuplex circuit of the main line Q Q, to Providence, where it is received by the No. 5 receiving relay. Finally, this relay, in its turn, through the intervention of the local battery L B, connected therewith, automatically repeats the message to No. 6 transmitter, over the No. 6 circuit to Boston, at which place it is received by the No. 6 receiving relay, by the operator stationed at the Morse instrument connected with that relay. This receiving relay is, in reality, shown in the drawing as connected with No. 1 transmitting instrument at Boston.

The purposes secured by means of this connection will be hereafter explained.

Briefly, the course taken by the message in its journeys to and from the two cities is as follows, viz.:

From Boston, by No. 1 transmitter over main line to No. 1 receiving relay at Providence.

From Providence, automatically repeated to No. 2 transmitter, and sent over main line through No. 2 sextuplex circuit to No. 2 receiving relay at Boston.

From Boston, automatically repeated to No. 3 transmitter, and sent over main line through No. 3 sextuplex circuit to No. 3 receiving relay at Providence.

From Providence, automatically repeated to No. 4 transmitter, and sent over main line through No. 4 sextuplex circuit to No. 4 receiving relay at Boston.

From Boston, automatically repeated to No. 5 transmitter, and sent over main line through No. 5 sextuplex circuit to No. 5 receiving relay at Providence.

Finally, from Providence, automatically repeated to No. 6 transmitter over the main line through No. 6 sextuplex circuit, to the No. 6 receiving instrument at Boston, where it is received by the operator.

It is not necessary, as might be supposed from the drawing, that the characters received on the group of segments comprising No. 1 circuit must necessarily begin to return on the next adjoining segment of No. 2 circuit. Suppose, for example, that a character concluded on the segments of No. 1 circuit, where the trailing contact indicates on the drawing. By the time the armature of the relay has moved in response to this character, and has placed No. 2 circuit in connection with the battery for return transmission, the trailing contact may be on the second or third contact of the No. 2 circuit. This, however, will make no difference, since both the distributing arms are synchronous, so long as the rotating arms pass over two or three of the No. 2 segments, while the armature of the transmitting magnet is in contact with either of the poles of the battery.

When we consider that a message made up of many words, each word containing numerous letters, each letter consisting of numerous separate and distinct characters, and each character, under the synchronous multiplex system, consisting of numerous impulses, was transmitted with certainty over a single wire, back and forth, this number of times, without the slightest interruption the one with the other, the fact almost challenges belief.

While these results may appear almost incredible, what I am about to describe may at first thought seem impossible. I will endeavour, however, to give such a description of this experiment as I saw it actually made, as will persuade the reader that so far from being impossible, its possibility must necessarily follow as a natural result of the exquisitely maintained synchronism secured by Mr. Delany's ingenious inventions.

After having successfully established by actual trial the possibility of the use of repeaters in his synchronous system, Mr. Delany connected the relay of the sixth circuit in Boston, where the message was received, with the transmitting instrument on No. 1 circuit. Now under these conditions, on making one dot on No. 1 instrument, this dot started on its zigzag way, to and from Providence, in the manner already described, only, instead of terminating on the sixth circuit in Boston, as in the previous experiment, the same dot was automatically retransmitted into the first circuit, and again sent on its journeying between the two cities, only on its arrival at the sixth circuit, in Boston, to be again automatically retransmitted over this same winding route.

An inspection of the drawing will render this connection clearer. Instead of the message being received by an operator stationed at the No. 6 receiving relay at Boston, this instrument is furnished with a local battery, L B, and connected by means of the conducting wire $z\,z$, and $z^1 z^1$, with the No. 1 transmitting instrument at Boston. By this means, therefore, the operator at the No. 6 receiving relay is dispensed with, since this receiving relay again automatically sends the signal by means of the No. 1 transmitting instrument on its zig-zag way between the two cities, until the No. 6 transmitter at Providence again sends it to the No. 6 receiving relay at Boston, which again automatically repeats it by the No. 1 transmitter over the six circuits between the two cities, and so on indefinitely.

In this manner, then, the original signal kept passing from city to city, over the different circuits, in perfect rotation, without the intervention of any operator, save the one who first started the signal on its ceaseless journeyings.

Timing the intervals of the returns of the original signal between the two cities over the sextuplex circuits, it was observed that it travelled between Boston and Providence over these six circuits 300 times; or covered the distance between Boston and Providence 1,800 times in each minute, thus making an entire distance of 1,500 miles a second, or 90,000 miles a minute; or for five minutes that a dot was kept going, the original signal in that short time travelled no less than 450,000 miles, or 18 times as far as the entire distance around the world at the equator.

Of course it will be understood that most of this time was taken up by the automatic movements of the armatures of the receiving relays, and the levers of the transmitting instruments. The experimental figures so obtained, however, furnish interesting data as to the rapidity, precision, and certainty with which these masses of matter may be influenced by the electric current.

An observer, noticing the progress of this experiment, and reflecting on the numerous complex conditions requisite for its successful accomplishment, cannot but be singularly impressed by its extreme weirdness. Bearing in mind the exceeding complexity of structure of the synchronous multiplex message, and the necessity for maintaining practically absolute synchronism between the distributing and receiving instruments at each end of the main line, a feeling of incredulity almost unconsciously arises in the listener's mind. Surely this weird traveller must miss some of his numerous connections, and once missed, his journeys are at an end for ever. But when the signals are heard recurring with their automatic regularity, as though tossed to and fro between the cities by a mighty juggler; when they are heard as mysterious whisperings in the air, that follow too rapidly on one another to permit more than a part to be intelligently received, we almost lose sight of the actual conditions of the experiment, and begin to vaguely doubt whether Mr. Delany has not received a visit from Puck, who is bewildered by the rapidity with which he is forced to travel; and when the strange repetitions of the original signal follow one another with such rapidity and regularity as to produce a kind of a prolonged but mysterious murmur, we are almost disposed to believe that these sounds are the plaints of the Wandering Jew, as he ceaselessly speeds on his never-ending journey.

Central High School, Philadelphia, August, 1884.

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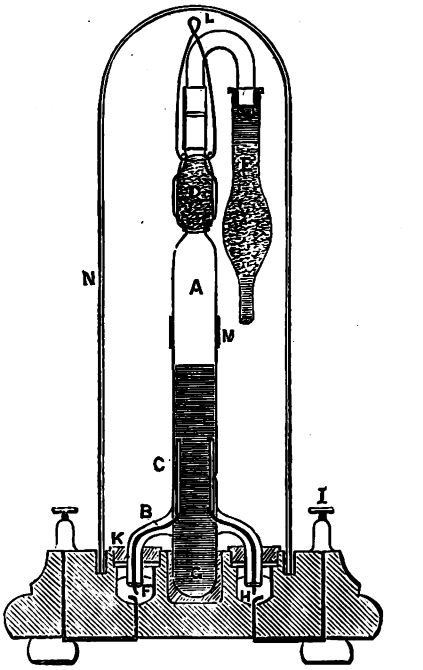
CORRESPONDENCE.

WEIGHT VOLTAMETER, FOR MEASURING ELECTRIC CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: While experimenting with apparatus for measuring electric currents, the idea of doing so by means of a weight voltameter suggested itself as being a method which, at all events, would have the advantage of being constant and unaffected by external agents, as temperature, pressure, magnetism, &c. The following is a brief description of one of the forms which I constructed and experimented with:—

Description.—It consists, as will be seen from the drawing, of a glass tube, A, provided with two arms, B B, containing the platinum wires, which are welded to and support the electrodes C C. The ball D is filled conveniently with pieces of thin glass tube. These serve to keep sparks of water from being mechanically carried over into the drying tube E, containing chloride of calcium. The stand has three circular cavities, F G and H. G holds the bottom of the voltameter, and F H accommodate its arms, B B. G and H contain



mercury, and are connected by copper wires to I. They are fitted on the top with round pieces of sheet rubber, which are fastened to and kept in their places by means of small portable wooden rings K; these rubbers being slit nearly across form valves, which permit of the apparatus being shifted about without loss of mercury, at the same time freely admitting the arms B B. These mercury pools form a cool and reliable connection, and to a great extent do away with the inconveniences and risks attending the direct connecting of the terminals with the platinum wires, as notably the heating of the junctions, and the cracking of that part of the glass into which the wires supporting the electrodes C C are fixed. N N represents a 9in. glass shade.

Taking a Measurement.—The terminals of the wires through which the current to be measured flows are fixed in the binding screws I, and the voltameter freed from air by allowing the electrolysis to proceed for a minute or so. It is now suspended from a balance by the wire L and weighed, then placed in the spring clip M; at a noted time the circuit is completed by pressing the arms B B into the mercury pools F and H. The electrolysis is continued for some minutes, when, at a noted second, the current is broken by raising B B out of the mercury. The voltameter is again weighed; the difference gives the exact quantity of water electrolysed. Now, referring to the known fact that "the amount of water electrolysed in a given time is exactly in proportion to the current strength, and a unit current decomposes ·0000945 of a grain of water in one second."

The current strength, then, in amperes is got by dividing the weight of water electrolysed by the constant ·0000945, multiplied by the time taken, reduced to seconds, thus:

$$C \times t \times \cdot 0000945 = \text{wt. water decomposed},$$

$$\therefore C = \frac{\text{wt. water decomposed}}{\cdot 0000945 \times t}.$$

Let W_1 = original wt. of voltameter,
W_2 = wt. after passage of currents,
T = time in seconds,
C = current in amperes.

Then $W_1 - W_2$ = wt. of water electrolysed,

$$C = \frac{W_1 - W_2}{\cdot 0000945 \times T}.$$

Example.

$W_1 = 52 \cdot 3215$ grams,
$W_2 = 52 \cdot 2199$ „
$T = 600 \cdot$ seconds,

$$\therefore C = \frac{52 \cdot 3215 - 52 \cdot 2199}{\cdot 0000945 \times 600 \cdot} = 1 \cdot 791 \text{ amperes.}$$

NOTE.—This form of voltameter is not adapted for the measurement of very strong currents, but more for laboratory and experimental work, where accuracy and constancy are of first importance. When the water acidulated with sulphuric acid requires renewing the apparatus is held by A in the warm hand, by which means some of the gases or air will be expelled. If now a little water (free from acid) be dropped into D, it will, on removal of the hand, be sucked into A.—Yours, &c.,

Govan. LAURENCE N. LEDINGHAM.

HEALTH EXHIBITION.—VIII.

One of the most enterprising and, as far as we can see, one of the most successful of electrical firms is that of Messrs. WOODHOUSE and RAWSON. This firm not only have about 2,000 of their incandescent lamps illuminating different parts of the Exhibition, but also a stand whereat the apparatus made by the firm is shown in action. Taking the apparatus pertaining to lighting first, or, at any rate, a portion of it, we notice that specimens of the various incandescent lamps made by the firm are exhibited. We know a literary confrère who is generally deputed to report shows for a certain paper. This gentleman maintains that it is impossible to say anything new about many of the exhibits at these shows, and so he takes his previous report, transposes a few words or sentences, it may be adds or subtracts words, and lo! the new report is done. Would that he had to write about incandescent lamps, for what can be said about them that has not been said before? Shall we say that Messrs. Woodhouse and Rawson will supply lamps of all kinds—for medical purposes, for microscopical, telescopical, for ordinary lighting, and for extraordinary lighting? They will supply the ballet girls with star lamps and batteries, or the gentlemen with an incandescent lamp for a scarf pin.

Those who have tested these lamps state that they are economical users of electrical energy, leaving for more extended experience the value of their lasting powers. Figs. 1, 2, and 3 show types of these lamps. The lamps intended for surgical purposes can be had with flexible stems, or stems containing water, so that great coolness can be obtained. One feature of the small lamps is noticeable. The efficiency is so high that the current they take is very small; the bulbs, therefore, unlike those of most small lamps now made, keep so cool that they can be allowed to touch the flesh while surgical operations are being performed. The method adopted for obtaining a variable resistance, so that the intensity of light may be altered at will, is worthy of notice. Two coils of German

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silver wire are wound spirally around the stem of the lamp; the coils are insulated from each other. A split ring which slides up and down these wires at will forms the contact maker. If the ring is raised to the top there is practically none of the wire in circuit; as it slides down more and more wire is brought into the circuit, till when at the lower end all the wire is in the circuit. One of the great hindrances to the extensive application of incandescent lamps for surgical and dental purposes has been the unwillingness of the members of the pro-

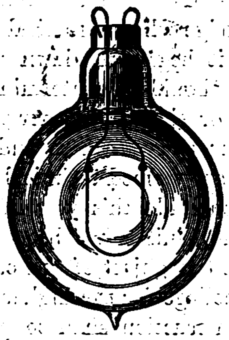
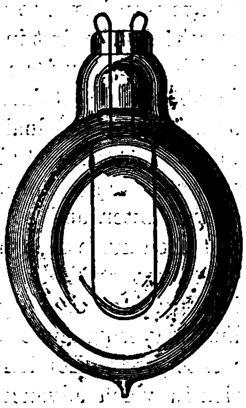

Fig. 1. Fig. 2. Fig. 3.

fessions to have anything to do with a battery which is at all "troublesome." This objection has, we believe, now been met by the introduction of a special arrangement of Leclanché battery, which will serve without recharging for about seven months. The recharging of this type of battery is, as every one knows, of a very simple nature. While this battery is being used for the purpose of every now and again enabling

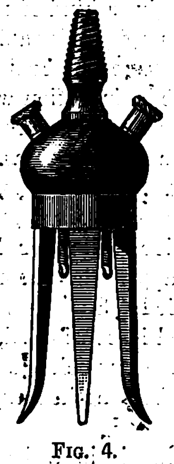

Fig. 4.

the dentist to examine the interior of the patient's mouth, it can at the same time be utilised for ringing the electric bells through a house, the lamps only requiring three cells.

The holder used with ordinary lamps is shown in Fig. 4, and it is claimed that a reliable contact is always made with this holder. It will be seen to be capable of being adapted to ordinary gas fittings, and even when the lamp vibrates a good

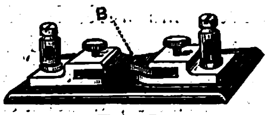

Fig. 5.

deal, as on board ship, the contact is still maintained. Writing just now of lamps for medical purposes reminds us that some excellent medical coils, complete with batteries (chloride of silver) are exhibited. Of wire the samples are numerous; whether the object is electric lighting, telegraphy, telephony, or modest electric bell work, something suitable will be found.

Fig. 5 shows one form of safety fuse used in incandescent lighting. A thin strip of foil, B, is placed upon a piece of vulcanised fibre, the fuse being inserted between the brass clips, as shown. Too large a current fuses a portion of the foil, and thus stops the current to the branch. Fig. 6 shows a safety plug, with box as it appears in practice. Another safety appliance which seems to act with extraordinary accuracy will be illustrated and described separately. Meanwhile we can say its action depends upon the attraction of an electromagnet upon its armature, the armature carrying two arms, which usually dip into mercury cups. When the armature is attracted by the magnet the motion breaks the contact of these arms with the mercury, and hence breaks the circuit. We watched one of these over and over again, acting with a current 4 per cent. greater than the normal current, and we believe they can be set much more delicately than this.

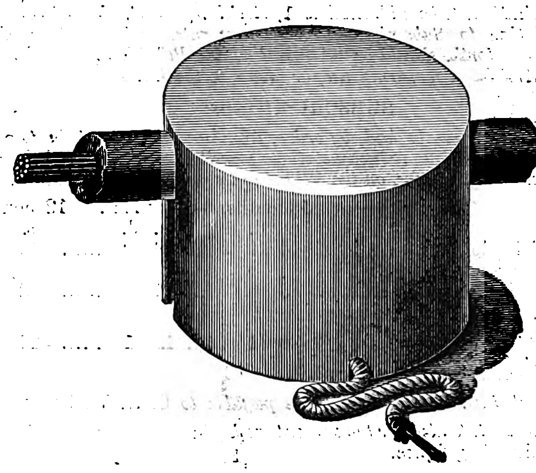

Fig. 6.

Among the minor requisites of electric lighting we may name "terminals," and of these a large variety are shown. The "locking" split terminal is perhaps the newest in design. In this terminal the arrangement is such that when the wire is clamped down the terminal is locked. The arrangement will be better understood by reference to Fig. 7. Messrs. Woodhouse and Rawson also exhibit a new make of cored carbon rods recently introduced. They are said to be superior to those which have hitherto been used, and by a special arrangement in manufacture are made more economically. There are also shown in action voltmeters and ammeters patented by Messrs. Cunyngham, Woodhouse, and Rawson. These have no permanent magnet, but measure the current by the attraction of

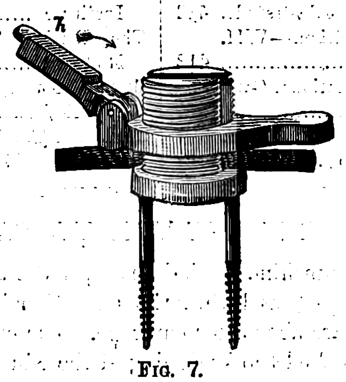

Fig. 7.

an electro-magnet on an armature. They are simple, and the only variable part being a spring similar to that used in Messrs. Siemens' instruments, are not likely to need re-calibration. They seem carefully made and tested.

One of the greatest wants—so say electric light engineers—is a good electric energy meter. Messrs. Woodhouse and Rawson exhibit a very taking meter, invented by M. J. Cauderay, of Lausanne, which will be fully illustrated and described in our next.

There are also various other exhibits shown by their Supply Department, which supplies all kinds of electrical goods not made by the firm.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

ANSWERS TO CORRESPONDENTS.

Correspondent (Stockholm).—*We cannot give the exact date of the continuation of the articles on "Elementary Electricity." The author has been otherwise busy; but we believe that he intends to contribute a number of articles during the forthcoming winter season.*

CONTENTS.

Notes 405
An Extraordinary Experiment in Synchronous-Multiplex Telegraphy. By Prof. E. J. Houston. Illustrated 410
Correspondence. Illustrated 412
The Health Exhibition.—VIII. Illustrated 412
The Coming Educational Campaign 414
Old Cable Stories Retold.—V. By F. C. Webb 415
Literature 416
Report of Committee on Gauge for the Manufacture of Small Screws 417
The City and Guilds of London Institute 419
The British Association at Montreal 421
Selected Correspondence 423
Companies' Share List 424
Telegraph Traffic Receipts for August, 1884 424

THE COMING EDUCATIONAL CAMPAIGN.

The waning sunshine reminds us that the time of recuperation is almost past, and that the educational labours of the winter session are about to commence. The end of September might well be called the beginning of the educational year, for it is then that many classes commence anew the various courses held to be necessary for preparation for various examinations. Before touching upon the purely electrical work, it may be well to inquire why so much trouble is taken over the teaching of science. The knowledge obtained is valuable in various ways. With it the imagination yields an inexhaustible fund of gratification, and affords a perpetual source of enjoyment, while the mere acquisition of knowledge is a reward in itself satisfying the innate principle of curiosity which all possess more or less; but the direct aim is to obtain knowledge that we may have power—power which rightly put forth leads to success. Such at least is the direct aim of those who have reached the age of discretion, while those still younger are having a course marked out for them which parents or guardians trust will lead to knowledge, power, and ultimate success. The text of to-day is—How to make money? The leading principle is money, and not that *Qui non recti instituunt atque erudiunt liberos, non solum liberis sed et reipublicæ faciunt injuriam.* (They who do not train and instruct aright their children as greatly injure the State as their offspring.) Twenty years or so ago men began to realise that two parts of a life were spent at school—the first in attending to those time-honoured studies which even now form the basis of our system; and secondly, in obtaining that knowledge which practical life required for application. Gradually it began to dawn upon the public mind that these studies should be conterminous and be completed during school life, or that the former should give place to the latter, and so year by year more and more provision has been made for what are termed technical studies.

A great stride has been made this year in that the central institution of the City and Guilds has been opened. A preliminary programme says the object of the central institution "is to give to London a college for the higher technical education in which advanced instruction shall be provided in those kinds of knowledge which bear upon the different branches of industry, whether manufactures or arts." The teaching at this institute is to be of a different kind to that in the Universities, inasmuch as it is understood more especially "to point out the application of different branches of science to various manufacturing industries." The students who enter the institution are supposed to have already obtained the knowledge of "principles" required, and so far as we can gather, the institution proposes to give a kind of two years' apprenticeship, during which time the pupil, under able and capable professors and demonstrators, will be directed how "theory is to be applied in practice." The intention we fear cannot be carried out in its entirety, and will degenerate more or less into preparation for certain examinations. We do not object to this, for we hold that a brave attempt, even at the impossible, will meet with a fair amount of success. The pupil, after his career at the institution, will enter business with more fully developed powers to apply the theoretic knowledge he has gleaned up to that period. So far as the special subject with which we are concerned is considered, it will be in the hands of Professor W. E. Ayrton, which is a sufficient guarantee that whatever is possible to be done in carrying out the programme will be done.

The electrical student is in a better position than other students in that the subject of electrical engineering is comparatively new, and the literature not very comprehensive. For some time the laboratory at the institution will run fairly with the factory, while this can hardly be the case in other branches of engineering. It must be remembered that Cambridge has for some years had the Cavendish laboratory, originally under the control of Clerk-Maxwell, now under that of Lord Rayleigh. Here, however, the work is of a more theoretical character than at the London Central Institution. The older establishments—King's College and University College, London—have their special classes, under Professor W. G. Adams and Professor Carey Forster respectively, where, perhaps, the studies take a mean between those at Cambridge and Kensington. But not only in London and in the older Universities do facilities for technical studies exist—the country is becoming dotted with younger colleges, which have, under the ablest professors obtainable, to carve out for themselves a niche in the educational system of the country. Newcastle-on-Tyne has Professor Herschel; Durham has Professor Garnett; Leeds, Professor Rucker; Manchester, Professor Balfour Stuart;

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Liverpool, Professor Lodge; Nottingham, Professor Heaton; Birmingham, Professor Poynting; Bristol, Professor Silvanus P. Thompson; and Cooper's Hill, Professor M'Leod. Then across the border we have the Universities of Glasgow and Edinburgh, with Professor Thomson and Professor Tait respectively; in addition to whom there are Professor Ewing, Dundee; Professor J. Blyth, and Principal Jamieson at Glasgow. Across St. George's Channel we come to Professor Barrett at Dublin, and so on. We should, perhaps, have added the School of Telegraphy, Hanover-square; the Crystal Palace Engineering School, the Hammond Company's School, although these are schools or colleges of a somewhat different character. To these must also be added the hundreds of schools in connection with the Science Department and the City and Guilds Institute. Consider, then, the vast amount of teaching power that is about to commence work for the session, and it will be understood that we ought to obtain indications that good work is being done. Never before has the science crusade been so complete. Not only the pupil but the world at large should benefit from such an array of talent. We hold that it is as much the duty of the professor and the teacher to contribute to the literature of his subject as it is to give certain lectures or lessons. A few sentences written by the late Dr. Todhunter may not be inappropriate here. He says, "Not only may we complain that those who possess such eminent endowments do not employ them, but we have the additional mortification of finding that those who could perform the required work well, though somewhat inferior to the great masters, are discouraged from attempting it by the conviction that at last their performance may be thrown into the shade by utterances from the oracles which have so long been dumb. I wish that those who occupy the highest places in professional science and learning would sometimes reflect on the fact that their eminence may be really an obstacle to the progress of knowledge if they communicate little or nothing themselves, for their reputation naturally deters others from attempting to produce works on the appropriated subjects."

OLD CABLE STORIES RETOLD.—V.

BY F. C. WEBB.

THE CAGLIARI, MALTA, AND CORFU CABLES.

(*Continued from page 366.*)

On 1st November, 1857, therefore, I found myself at Cagliari, and before I proceed further let me point out to those who may have to refer to this town by name for the first time that it is by Englishmen often erroneously pronounced Cagliâri. The French quite as erroneously call it Cagliarî, whereas the Italians—and I suppose they ought to know—call it Câgliari. I was there with Mr. Newall for several days before we started and once or twice afterwards, and I have a kindly—I might say a "lively"—remembrance of the place, in spite of many of the "petites misères de la vie," which abound there. In the first place I never knew any town where church bells kept up such a ringing and clashing. As fast as you thought you had heard the end of a tolling in one quarter a fresh peal would burst out in another. I believe half an hour in Cagliari would drive even a Salvation "Captain" mad. And then the mosquitoes, with no curtains to your bed. But, oh, the chamois! I mean the chamois mentioned by Mark Twain in his "Tramp Abroad." I don't think even Mark Twain could have found such a quarry for chamois as Cagliari. Ladies in Cagliari, so I was credibly informed, at an evening reception, think nothing of taking a "chamois" off another lady's white dress, with a graceful bow and a "scusate," and giving it a pinch, and throwing it aside. The chamois abound all over the floor in the chinks of the red tile pavement. But then this is scarcely to be wondered at. The wash-hand basins are of the smallest possible dimensions, and even this small item it was difficult to get emptied and replenished. After stamping, and fuming, and bawling, a waiter would at last appear, and, sulkily taking the small basin in one hand, would sprinkle the dirty contents over the floor, evidently to feed the chamois. When these small but lively animals are deliberately fed in this manner, how can you expect them not to appear at evening parties? It is these "chamois" that gave me a lively remembrance of Cagliari.

The Cagliarites, I learnt, are very proud of their town, which runs up the side of a hill, bearing a resemblance to Algiers, though I do not know that there is much to boast of in that. I can recollect, however, some mountains on the opposite side of the bay, which at times in the evening presented such lovely tints of purple and blue as would delight the eye of an artist, and puzzle him to reproduce.

Cagliari, I found, was the birth-place of Mario, and I felt infinitely more pleasure in gaining information about that idol of my early days than I am afraid I shall ever feel about the antecedents of any telegraphic or electrical knight or baronet past or present. But this is not the journal in which to write what I gleaned, and I must pass on to the dry and threadworn subject of cable laying.

H.M.S. "Desperate," a screw corvette, was at Cagliari waiting for us. She was told off by the Admiralty to assist us, as the Cagliari, Malta, and Corfu cables were to be laid for the Mediterranean Extension Telegraph Company, which company had a guarantee (as long as the cables were in working order) from our Government. In those days submarine cable expeditions frequently had the assistance of Her Majesty's ships. Lieutenant Watson, who was first lieutenant of the "Royal Albert" flag-ship at Malta, was in temporary command of the "Desperate," and a very nice fellow he, Lieutenant Watson, was. We went round on November 1 in his gig to look at the landing-place for the cable near Cape St. Elias, a few miles from Cagliari.

The "Elba" did not arrive until the 10th, and during the interval of ten days the "Desperate" went out and took soundings, and we made two trips in the "Blazer" to Chia to take tests of the Bona cable. The English Consul at Cagliari, who was a Scotchman, dined with us once or twice, and I recollect that he spoke Italian with a strong Scotch accent, which was very peculiar. Yet he had been Consul there for many years, and the Italians could never make out why he had that peculiar pronunciation. The "Elba" had had a fearful passage across the Bay. She had lost three boats and the carpenter, and part of her bulwarks. There were no Plimsoll marks in those days, and the ship was very deeply laden—in fact too deeply, for when she arrived after burning all her coal she had only fifteen inches free board. The chief officer described to me that the covered passage on each side of the deck house was at times completely filled with green sea. Had a hatch-cover given way she must have gone down like a stone. The crew had at one time begged of the captain to turn back, but the old man stuck to his orders and came on. We did not consider it safe to go to sea and have the hatch covers off without taking first thirty miles of deep sea cable out of her aftermost hold to lighten her. We got the brake off the "Blazer" by means of the "Desperate," and then the "Elba" went alongside the "Desperate," and took it in. The coils in the "Elba" were all circular wooden structures, with cones and rings. The coils were as follow:—

	D.S.	S.E.
Fore	388	—
Main	492	—
After	10	9·5
	—	7·5
Aftermost	70·	—
	960·	17·0
	17	
Total	977	

The deep sea weighed nearly a ton to the mile, but I forget

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what the shore end weighed, probably about five tons to the mile. There was no picking up gear or bow sheave, but there was a dynamometer, which answered fairly well. A rough sketch of this is given in the report of what I said at the discussion of one of the papers on submarine cables at the Telegraph Engineers, but I forget the date. We anchored close to landing place on the 13th. When we were placing the buoy down a few days before, I had constantly urged its being placed further out than even where Lieutenant Watson thought safe—and this was further out than Mr. Newall wanted it—so as to provide for the wind coming on the land and the ship tailing in, and I shook my head when Lieutenant Watson at last said, "Well, Webb, surely here will do," and down went the buoy. Events proved I was right. It was not far enough out. We got 500 yards of shore end into boats, and commenced landing end, but ran short and got some slack from ship, and at last got end ashore at 8 p.m. in the dark, and *joined it on to land wires*—a horrible thing to do, but no hut had been provided. This was a sin we had never perpetrated on any of the work I did for the Electric Telegraph Company. We laid at anchor all night, with our head in towards land, the wind being off the land. At daylight we under-run cable to shore to see there were no kinks and found all right. Weather then looked bad, and we determined to wait a bit, and Mr. Newall and Mr. Liddell went to Cagliari. They had not gone long before the wind came on the land, and the ship tailed round and struck on the rocks. The "Blazer" saw what had occurred and came down to us, and we got a hawser out to her. The ship hung fast for twenty minutes and then started off. We paid out a bit of slack we had on the forecastle, but ran short, and as bight went over got some kinks in. Got them on board and cut cable. Tested to shore and found dead earth. Disconnected land lines. Still dead earth. Under-run off and found ship had grounded on the cable and smashed it flat. Cut cable and hauled end from ship and made splice in boat. All this trouble and a narrow squeak of losing the ship through anchoring too close in order to save the trouble of landing a few fathoms more cable in boats.

(TO BE CONTINUED.)

LITERATURE.

Dynamo-Electric Machinery: A Manual for Students of Electrotechnics. By SILVANUS P. THOMPSON, B.A., D.Sc., &c. [London: E. and F. N. SPON, 1884.]

FIRST NOTICE.

The steam engine has a distinct literature of its own. It seems that a new implement of torture to rack the brains of the scientific world has been found in the shape of dynamo-electric machinery, demanding and, we may say, deserving a literature of its own. Professor Thompson is the first to contribute a text book to this literature, and probably never in the whole history of the applied sciences has a more satisfactory first step been made. The author has long been known as a careful and conscientious electrical student. His Cantor lectures upon this subject proved that clearness of statement and breadth of grasp of the subject were combined in the author, indicating his fitness for such work as he has now completed. This work is based upon the Cantor lectures, and the author's aim in adding and rearranging "has been to make the work a manual for students of electro-technics, for whom no text book of this branch of science has hitherto been available" (preface). Acknowledgment is made to those who have assisted the author in any way, and then, still in the preface, he points out the recent growth of this branch of knowledge, and the consequent liability to err, asking for further information from those who are in a position to give it. Of the mathematical work of Clausius concerning the theory of the dynamo, we read "This mathematical *tour de force* is, however, fatal. The new constants have no physical significance whatever, and simplicity is gained by sacrificing their utility. The mathematical triumph remains a Pyrrhic victory."

The true mathematical theory is the work of the future, for its true basis is as yet wanting. The field for practice is as open and extensive as the field for theory, and "as with the steam engine so also with the dynamo machine, there will probably be a constant and progressive evolution, finally settling down upon two or three typical forms, which will survive the many comparative crude machines which as yet have taken shape and come into active service."

In this our first and preliminary notice of a work opening up an entirely new field we shall content ourselves with merely describing what the book contains without entering at all into the value of the methods adopted or the correctness of the statements. In fact, we want simply to tell readers what they may expect to find in the work, though, at the same time, we may go so far in criticism as to say that our examination of it has led us to the conclusion that it is well worth reading, and so far as electrical literature is concerned will be *the* work of the season. Physical, Algebraical, Geometrical: the dynamo machine has been viewed from these three points of view. We have firstly brought before us the methods employed in exciting the field magnets, then the action of induction, with a classification of dynamos based upon inductive action. The armature is described, from the ideally simple to those used in practice, and their connection with the "collector." The physics of armatures and field magnets are considered, in which might really be included the chapter on the government of dynamos. Chapters VII.—IX. inclusive are almost wholly devoted to the description of *typical* dynamos. We have italicised the word typical, because the author has exercised a wise descretion in leaving out descriptions of historical and obsolete dynamos and others that really possess no individuality except to the inventors and patent agents.

Chapters X.—XVI. deal with the algebraic theory of the dynamo, then follow eight chapters discussing the geometrical theory of the dynamo. So far as we know, this is the first time any systematic attempt has been made to deal with geometrical matters in connection with dynamos. Of course, the method has been frequently adopted in isolated papers, but here we have it considered more as applicable to a whole theory than to mere parts. We must again mention that we are not now dealing critically with the text, and in passing over without comment the notation adopted and the introduction "gauss," to express unit of field intensity, it must not be taken that we agree with either notation or nomenclature. The remainder of the book deals with the testing of dynamos, together with various appendices referring to special points. A capital index is furnished, and the book is admirably illustrated and printed. One feature which calls for our thanks is that the author has had no hesitation in repeating illustrations when the repetition of the illustrations would save the reader trouble in referring back.

TELEGRAPH AND TELEPHONE WIRES IN NEW SOUTH WALES.—Mr. E. C. Cracknell, Superintendent of Telegraphs, has designed an improved plan for carrying telegraph and telephone wires overhead, and the Government have approved of the design, and accepted a tender from Messrs. D. and W. Robertson for the supply of the ironwork necessary for testing the value of the design in Sydney. As the wires on the telegraph posts in Sydney are very numerous, and the necessity to adopt some other method of carrying the wires is very urgent, Mr. Cracknell has devised a scheme by which the wires will be bunched together in cables. The plan consists of erecting an ornamental frieze on cast-iron standards, cable racks being fixed at the rear of the frieze as places in which the cable may rest. Each cable will contain 50 wires, and in the design for which a tender has been accepted racks are provided for 400 wires. The number of racks, however, may be increased indefinitely. When, in the erection of the frieze and standards, the intersection of a street is met with the cables will be carried through underground pipes below the gas, water, and sewerage, and a plan will be adopted by means of an endless wire to enable the officials of the Telegraph Department, at any time that it is necessary, to have new cables drawn into the underground pipes at the intersection of streets.—*Colonies and India.*

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REPORT OF COMMITTEE ON GAUGE FOR THE MANUFACTURE OF SMALL SCREWS.*

BRITISH ASSOCIATION, MONTREAL, 1884.

1. Since the presentation of its first report on a gauge for small screws at the meeting of the Association held in 1882 at Southampton, this committee has further examined into the recommendations there made, with the result that they now have to propose some important modifications, the general effect of which will, it is felt, be to materially facilitate the introduction of the system.

2. The want of unanimity on the part of the committee referred to in paragraph 7 of that report arose mainly on the question as to whether the inch or millimetre should be taken as a unit of measurement. It is evident that if either is rigidly adhered to, and in any way employed in the nomenclature of the screws, as, for example, in specifying the diameter, pitch, or threads per inch or per mm., the same dimensions could not be expressed in whole numbers in the other unit, and thus a material obstacle would be at once introduced to its general adoption.

PROPOSED SMALL SCREW GAUGE.

Number.	Nominal Dimensions in Thousandths of an Inch.			Absolute Dimensions in Millimetres.	
	Diameter.	Pitch.	Threads per inch.	Diameter.	Pitch.
I.	II.	III.	IV.	V.	VI.
25	10	2·8	353	0·25	0·072
24	11	3·1	317	0·29	0·080
23	13	3·5	285	0·33	0·089
22	15	3·9	259	0·37	0·098
21	17	4·3	231	0·42	0·11
20	19	4·7	212	0·48	0·12
19	21	5·5	181	0·54	0·14
18	24	5·9	169	0·62	0·15
17	27	6·7	149	0·70	0·17
16	31	7·5	134	0·79	0·19
15	35	8·3	121	0·90	0·21
14	39	9·1	110	1·0	0·23
13	44	9·8	101	1·2	0·25
12	51	11·0	90·7	1·3	0·28
11	59	12·2	81·9	1·5	0·31
10	67	13·8	72·6	1·7	0·35
9	75	15·4	65·1	1·9	0·39
8	86	16·9	59·1	2·2	0·43
7	98	18·9	52·9	2·5	0·48
6	110	20·9	47·9	2·8	0·53
5	126	23·2	43·0	3·2	0·59
4	142	26·0	38·5	3·6	0·66
3	161	28·7	34·8	4·1	0·73
2	185	31·9	31·4	4·7	0·81
1	209	35·4	28·2	5·3	0·90
0	236	39·4	25·4	6·0	1·00

3. It should be pointed out, however, that it has hitherto been the common practice to designate such small screws as the committee alone is considering, not by any specific dimension, but by a number, which as a rule is arbitrarily chosen and does not of itself form a guide to the size of the screw. Considering, then, that the unit of measurement is only indirectly connected with the subject of a screw gauge, the committee has felt that the two units might be reconciled so far as relates to such a subject, and that thus one important difficulty would be removed.

4. The manner in which the series of screws adopted lately by Swiss manufacturers is correlated has been well explained in the previous Report, and full explanations are given in the two original pamphlets to which reference is there made.* The diameter D is related to the pitch P by the formula $D = 6 P^{\frac{6}{5}}$, (1) all measurements being in millimetres, and P having successively the values 1 (or $0·9^0$) mm., $0·9^1$ mm., $0·9^2$ mm., $0·9^3$ mm. . . . $0·9^n$ mm.

Thus *n*, the index, becomes a convenient designating number for the screw, and the formula (1) may be expressed $D = 6 (0·9^n)^{\frac{6}{5}}$, where $P = 0·9^n$.

5. The pitch of any screw can be at once ascertained from its designating number by raising 0·9 to the power indicated by that number, and from this pitch the diameter is directly deducible by the formula (1), so that the number (*n*) given in the first column of the table, by which a screw is known, is intimately related to all its dimensions.

6. It is evident that, by taking the exact successive powers of 0·9 for the pitch, complex numbers would soon be arrived at. Such dimensions would, however, involve a degree of accuracy which is hardly attainable in practice, and it may be shown that, with two significant figures employed throughout to express the pitch, the degree of accuracy likely to be attained in screws of the kind under consideration is reached. Relying on this fact, the series of pitches given in Column VI.† is arrived at for screws ranging from ·236in. to the smallest in use, 0·01in. in diameter, in place of the mathematically exact series obtained by raising 0·9 to successively higher powers.‡ And this is the series which the committee recommends for adoption.

7. Viewing the numbers thus obtained in the first place merely as a graduated series of pitches, and ignoring the unit of measurement, it may be admitted that the series of powers of 0·9 from which they are deduced is perhaps as good a one as can be suggested for the purpose, and it is found to very closely correspond with experience. Thus Column VI., which gives the nearest approximation to this series that is practically required, is well adapted for such a system of screws. It is to be observed that in selecting a series of pitches there are three simple alternatives to choose from:—(1) to have a constant arithmetical difference between successive pitches, in which case either the pitches of small screws would differ by too great an amount, or those of the larger screws by too small an amount; or (2) to divide the entire range into sets, in each of which the differences are constant. The third alternative is to take successive powers of some other simple fraction, for example 0·8, but such a series would not so well correspond with the screws most generally employed.

8. Accepting this series, it may, however, be urged that it should be based on some aliquot part of an inch rather than on the millimetre. But any advantages to be gained by such a modification are inappreciable, for an examination of the numbers at once shows that they are for the most part awkward fractions of a millimetre, and the metric system of measurement thus enjoys no advantage in this respect over that based on the inch. From the point of view of interchangeability, however, of screws to be manufactured in this country and on the Continent, it is essential that the same basis of measurement of the pitch be everywhere adopted;

* Second Report of the Committee, consisting of Sir Joseph Whitworth, Sir W. Thomson, Sir F. J. Bramwell, Mr. A. Stroh, Mr. Beck, Mr. W. H. Preece, Mr. E. Crompton, Mr. E. Rigg (secretary), Mr. A. Le Neve Foster, Mr. Latimer Clark, Mr. H. Trueman Wood, and Mr. Buckney, appointed for the purpose of determining a gauge for the manufacture of the various small screws used in telegraphic and electrical apparatus, in clockwork, and for other analogous purposes.

* *Systématique des vis Horlogères*, by Professor M. Thury, Geneva, 1878. *Notice sur le Système des vis de la Filière Suisse*, Geneva, 1880, by the same author.

† It may be incidentally pointed out here that this series comprises two screws, with pitches of 1 mm. and 0·25 mm., which would be serviceable for micrometers.

‡ Sir Joseph Whitworth's gauge, in general use, ends at ¼in., where this commences.

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because, having agreed upon only two significant figures on one basis, terminal decimals are obtained, but such terminable decimals could not be accurately expressed by two significant figures on the other basis of measurement.

9. Again, it is to be remembered that the use of metric measurement to designate the pitch need not inconvenience English manufacturers who are desirous of cutting the screws in their lathes. For, as has recently been pointed out by Mr. Bosanquet,* it is easy to cut a thread whose pitch differs from one millimetre by an amount which may for all ordinary purposes be neglected ($\frac{1}{55,300}$th), with a guide screw based on the inch by the addition of a wheel of 127 teeth, and thus the series here recommended could, on the rare occasions that it became necessary, be originated on any screw cutting lathe provided with the requisite wheels. But the committee do not consider it needful to specially contemplate facility in the originating of the threads, as the screws under consideration are made in a plate or by the aid of dies, and manufacturers on a large scale would be provided with a special lathe for the purpose.

10. Whether the inch or millimetre is adopted as a unit of measurement the series of pitches for these small screws becomes an ideal rarely attained in practice, for with screws tapped in a plate, or even with dies, the exact pitch aimed at will often not be attained; neither is it safe to assume that two screws, tapped in corresponding holes in different plates, will have precisely the same number of threads per inch. This is especially the case with the smaller screws, as may be proved by accurately measuring the pitches of several tapped in holes that are nominally alike.

11. The fact here stated affords a reason against extending the practice of designating screws by their number of threads per inch, already sometimes resorted to in the case of large screws, to the screws now under discussion. It is found that screws, nominally alike, frequently differ in this respect by as much as five or even ten threads in the inch, nor need this occasion surprise when it is remembered that the screw-plates employed must expand to varying extents in the hardening, that the hole is often not more than three or four threads deep, and that the pressure applied by hand must vary considerably. Such a nomenclature would thus involve the use of inconveniently high numbers to express a minute degree of accuracy but seldom attained, while they convey but little real information, since mere examination would not enable any one to distinguish between, say, a screw of 169 and 181 threads per inch.

12. The series of diameters must next be considered. Before the formula $D = 6\,P^{\frac{6}{5}}$ was adopted, it was ascertained by the minute examination of about 140 small screws that the series very closely corresponds with those recognised as good in the trade, and the screws made in the new plates, known as *filières Suisses*, which the committee have had an opportunity of examining, appear to them to be well proportioned in this respect. The series of diameters, like the pitches, are expressed by two significant figures in each case, as the values for D deduced from the formula (1) are necessarily indeterminate in most cases. These diameters are given in millimetres in Column V., and their nearest equivalent in thousandths of an inch in Column II. As the committee considers that these screws are well proportioned as regards pitch and diameter, and approves the formula (1) being take as a basis, it is led to recommend this series of diameters being adopted in conjunction with the pitches already discussed. It has been suggested to the committee that the introduction of such a system into general use in this country might be facilitated by punching against each hole in the screw-plate, side by side with the designating number, as given in Column I., the approximate diameter of the screw made in it, as expressed in thousandths of an inch (Column II.), as these numbers would convey a meaning to English workmen more definite than the numbers in Column I. or V. The committee sees no serious objection to such a course; but it should be remembered that screws have hitherto always been recognised by a number seldom higher than 25, and it may be questioned whether any substantial advantage is gained by substituting such high figures as are involved in the expression of the diameters.

13. It will be seen that the series here recommended gives 26 screws for the range from $\frac{1}{4}$-inch to the smallest in use. Comparing this number with those of two of the best systems commonly met with—namely, the Latard (Perrelet et Martin) and Bourgeaux plates, we find that—

For a range of 21 sizes of watch screws on the Latard plate, this gives 15
For a range of 23 sizes of watch screws on the Bourgeaux plate, this gives.. 17
For a range of 36 sizes of clock screws on the Latard plate, this gives 23

The entire series is thus less than that of well-established plates, and cannot, therefore, be considered greater than the requirements of practice demand; while the fact that the watchmakers (who probably require the most extensive assortment of screws) in Switzerland have accepted it, confirms the committee in its opinion that the series is not deficient in this respect.

14. It remains to consider the form of thread. There are so many practical points to be taken into consideration in discussing such a question that it becomes specially useless to rely much on theory for guidance, and the divergence observable among the forms adopted by different manufacturers is thus very great.

The most important points to be borne in mind in its selection are:—

(1) The threads must be easily cut with the class of screw-cutting tackle ordinarily met with in workshops.

(2) The strength of the threads on the male and female screws must be so correlated that the liability of either to strip is a minimum.

(3) The resistance of the core to torsional stress when force is applied in rotating the screw must be a maximum.

(4) The friction should be as small as possible, in order to reduce wear.

15. In regard to the first of the above conditions it is to be observed that very many of the screws considered by the committee are usually made by means of a plate, in which are round, tapped holes. Such a hole forms a thread by causing the metal to "flow" from a space towards a thread, and its action is obviously of quite a different character from the cutting action of dies or of a chasing tool. In the case of plates with notched holes the cutting and squeezing actions are combined.

16. As bearing on the second condition, it is evident that, as the strength of the threads depends so essentially on the materials of which the screw and nut are made, and these are very varied, no precise and invariable rule is attainable. If strength were the only point to be considered, a purely triangular form without any rounding would be best, contact being assumed to take place over the entire surface. But in practice it is impossible to secure such perfect contact, and it becomes needful to round off the crests from all the threads; and this rounding is the more necessary as the screws are smaller and irregularities in the manufacture become relatively more marked. This modification is also necessary in view of condition (1) already considered.

17. The third point—namely, the resistance of the core to torsional stress—is determined primarily by the depth of thread. If the sectional area of the ring cut away is less than that of the core, the probability of the latter breaking across may be regarded as approximately equal to that of the threads stripping; but it is impossible to maintain a constant ratio, as such a condition would require the thread to be so fine in the case of small screws that there would be no sufficient hold in the nut. Thus in the very smallest screws (those below ·030in. in diameter) the ratio $\frac{\text{area of core}}{\text{sectional area of thread}}$ is less than 1, and it gradually increases till a proportion of between 2 and 3 is attained.

* *Phil. Mag.* (Fifth Series), Vol. XV., pp. 217, 438.

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18. Condition (4) is evidently best satisfied by a square thread. Such a form is, however, impracticable in the case of the small screws under consideration, but it is obviously approximated to according as the angle of a triangular thread is made less and the rounding greater.

19. The angles that have been adopted in practice show, as might be expected, considerable variation. On the one hand, an angle of 60° is rarely exceeded, the thread being thus derived from the equilateral triangle, and, on the other hand, 45° may be taken as the lower limit.

20. The depth of a thread is evidently a function both of its angle and of the amount of rounding at the top and bottom. It may conveniently be expressed as a fraction of the pitch (taken as unity). In the case of the small screws in general use the mean value of the depth thus expressed is found to be 0·563, the maximum being 0·771, and the minimum 0·311. It is evident that any increase in the depth beyond what is essential will materially and needlessly increase the difficulty of manufacture when a screw-plate is used; at the same time the depth must not be too much reduced on account of the greater tendency of the thread to strip. It is further important that the additional torsion involved in cutting a deep thread, which materially increases the risk of tearing the metal across, should not be lost sight of.

21. The committee, after comparing together a large number of different forms of thread, some of which are in actual use, while others have only been suggested, were much tempted to recommend the Whitworth thread for adoption by the British Association, because it is so well known in this country, and experience has proved indisputably that it is excellent when employed for engineers' bolts, &c. But, as appears from sections 16 and 18, in the case of small screws the tendency should rather be to increase the rounding on account of the difficulties of manufacture, and the depth of the Whitworth thread is 0·64 of the pitch, which is considerably in excess of 0·563, the average adopted in practice. The Whitworth thread is, moreover, characterised by a greater angle than is usual in small screws.

22. The advisability of modifying the form of thread of small screws as compared with those of greater diameter is fully recognised by the Swiss Committee, their thread for the former having an angle of 47½°, while that for the latter is 53°, nearly the same as that of the Whitworth thread. In the case of small screws made in the *filière Suisse* the crest of each thread is rounded off with a radius equal to $\frac{1}{6}$th the pitch, and the hollow with $\frac{1}{5}$th the pitch. The actual depth is 0·60 the pitch, somewhat less than in the Whitworth thread.

23. While approving the general form of thread here described, this committee could not but feel that the difference in the roundings ($\frac{1}{6}$th at the top and $\frac{1}{5}$th at the bottom) was unnecessary. Looking, moreover, to the fact that very many of the screws of the sizes now under consideration are for electrical and telegraphic instruments, and, therefore, may be of brass, and that, with threads of such dimensions, it is impossible for the eye to ascertain whether a given screw satisfies the required conditions in regard to such small differences between the crest and hollow of the thread, the committee feels that an equal rounding ($\frac{2}{11}$ths of the pitch) at the top and bottom would be preferable. This would maintain the angle of thread and the depth the same—namely, 47½° and $\frac{3}{5}$ths of the pitch respectively.

24. Having now discussed the three main points that require to be considered in any system of screws—namely, the pitches, diameters, and form of thread, it seems desirable to enumerate briefly the recommendations at which the committee has arrived. These are :—

(1) That the series of diameters for screws from $\frac{1}{100}$th inch to $\frac{1}{4}$th inch be that given in millimetres in Column V., the nearest thousandths of an inch being given in Column II.; these diameters being the series calculated by making P, in the formula $D = 6 P^{\frac{6}{5}}$, have in succession the following values :—

1 (or $0·9^0$) mm.; $0·9^1$ mm.; $0·9^2$ mm.; $0·9^3$ mm.; . . . $0·9^n$ mm.

Only two significant figures are taken to represent the diameters.

(2) That the pitches of these screws be the above gradually decreasing series, each pitch being $\frac{9}{10}$ths of its predecessor, but that only two significant figures be used in their expression. The series thus obtained is given in Column VI.

(3) That in view of the desirability of securing a system of small screws, international in its character, English manufacturers of screws, screw-plates, &c., adopt the exact pitches given in millimetres in Column VI., which, as explained in par. 9, can, if required, be originated on an English lathe. Further, in view of the fact that small screws and screw-plates, while nominally alike, will not unfrequently differ considerably as regards their number of threads per inch, the practice of designating such screws by their number of threads per inch should not be adopted. For reference, however, the approximate number of threads per inch, as calculated from the pitch given in Column VI., are given in Column IV.

(4) That the designating numbers given in Column I., being the indices of the powers to which 0·9 is raised to obtain the pitch, be punched against each hole in the screw-plate, and that, if thought desirable, its diameter in thousandths of an inch (Column II.) might be punched side by side with this number.

25. In his "Systématique des vis Horlogères," Professor Thury has done for the small screws used by watch, clock, and scientific instrument makers what was done forty years ago by Sir J. Whitworth for the larger screws used by engineers; and, like the admirable system introduced by the latter, the scheme here advocated is based on the data obtained by measuring the several dimensions of many screws accepted by practical men as being well proportioned.

26. The committee has had an opportunity of examining both screws and screw-plates (for the smaller screws) made on this system, which, it is convinced, will satisfy all the demands of practice. The committee can therefore confidently recommend its adoption by the British Association, subject to the slight modification discussed in paragraph 23; and it feels that an important incidental advantage would be the support it would at once receive on the Continent, and the consequent increased rapidity with which it might be expected to come into general use; for it cannot be doubted that its recognition by so important a body as the British Association would have considerable influence in establishing the system abroad.*

THE CITY AND GUILDS OF LONDON INSTITUTE.

Preliminary Programme of the Central Institution.

The object of the Central Institution is to give to London a college for the higher technical education, in which advanced instruction shall be provided in those kinds of knowledge which bear upon the different branches of industry, whether manufactures or arts. The institution is intended to afford practical scientific and artistic instruction which shall qualify persons to become (1) technical teachers; (2) mechanical, civil, electrical, chemical, and sanitary engineers, architects, builders, and decorative artists; (3) principals, superintendents, and managers of manufacturing works.

The main purpose of the instruction to be given in this institution will be to point out the application of different branches of science to various manufacturing industries; and in this respect the teaching will differ from that given in the universities and in other institutions in which science is taught rather for its own sake than with the view to its industrial application. In order that this instruction may be efficiently carried out, the institution, in addition to the lecture theatres and class rooms, is fitted with laboratories, drawing offices and workshops; and opportunities will be afforded for the prosecution of original research, with the object of the more thorough training of the students, and for the elucidation of the theory of industrial processes. The courses of

* The recommendation for the appointment of this committee having failed to reach the Committee of Recommendations at Southport in time to allow of its sanction by the General Committee, the Council at their meeting on November 6th, 1883, requested the committee to continue their labours, and undertook to recommend to the General Committee at Montreal that this report be printed among the reports.

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instruction will be arranged to suit the requirements of—1. Persons who are training to become technical teachers. 2. Persons who are preparing to enter some industrial or professional career. 3. Persons who desire to attend special courses, with the view of acquainting themselves with the scientific principles underlying their work.

Students intending to go through the complete course of technical instruction with the view of subsequently obtaining a diploma, will be required to pass an entrance or matriculation examination, which will include mathematics, pure and applied, chemistry, physics, drawing and French or German. The fees for the complete course of instruction to be pursued by a matriculated student will be £30 per annum, payable in advance. The fees for separate courses, including laboratory work, will be from £10 to £30. Students wishing to attend separate courses will be required to satisfy the professors that they possess sufficient knowledge to follow such courses.

The hours of attendance at the institution will be from 9:30 a.m. to 5 p.m. on five days a week, with a short interval for luncheon. The first session of the institution will commence on Monday, January 12th, 1885, and the fee for students then admitted will be £20 till the close of the session.

The entrance examination will be held on Tuesday, December 16th, and on the three following days, and will be open to all persons who are not less than 16 years of age at the date of the examination. On the results of the examination, the following scholarships will be awarded to students who are prepared to attend the complete course of instruction in any one department, provided that the merits and circumstances of the candidate justify the committee in making the award.

(1.) The Clothworkers' Scholarship of £60 a year, tenable for two years and renewable for a third year, entitling the successful candidate to free education.

(2.) The Siemens Scholarship of £50 a year for three years founded by Lady Siemens in memory of her husband, the late Sir William Siemens, LL.D., F.R.S. This scholarship will be competed for in October, 1885.

(3.) The Royal Albany Scholarship of £50 a year, for three years, founded by by the Corporation of London in memory of the late Prince Leopold, Duke of Albany.

(4.) Two Mitchell Scholarships of £30 a year, for two years, one with, and one without, free education, to be awarded to candidates who have attended a public elementary school within the City of London, or whose parents are, or have been, resident or engaged in some trade or occupation within the City of London.

Further particulars of the conditions of the tenure of these scholarships may be had on application.

Arrangements will be made for special courses of lectures and laboratory work to commence in June, 1885, and to continue for six weeks, adapted to the requirements of teachers of classes in technology registered by the institute. The instruction to be given in these courses will comprise laboratory work under the direction of the professors of the institution, and special lectures on the technology of particular industries to be given by the professors, or by the institute's examiners, or by other qualified persons. Registered teachers of the institute will be admitted, on the recommendation of the director, to these summer courses, without payment of any fee.

These courses will be open to a limited number of other persons who can satisfy the professors that they are qualified to profit by the instruction. The fee for persons other than registered teachers admitted to these courses will be £2 for a course of 20 lectures and £5 for the corresponding laboratory course.

Persons wishing to become students of the Central Institution must send in, not later than December 1st, 1884, a written application, accompanied by a certificate of birth and a short account of their previous training. Candidates for the entrance examination will be required to pay a fee of £1, which in the case of those who succeed in passing will be deducted from the amount of fees payable on entrance; in the case of candidates who fail to pass, the fee will be retained, but the candidate will be admitted to any one subsequent examination without payment of an additional fee. In the case of candidates obtaining a scholarship with free education the fee will be returned. A diploma stating the industry or branch of engineering in which he is qualified will be awarded to the student who shall have gone through a complete course of instruction as laid down in the programme, and shall have satisfactorily passed the several examinations. This diploma, which will be given, on the recommendation of the professors, will entitle the student to the associateship of the institute. The fellowship will be conferred upon those who, having obtained the associateship, shall have spent some time in actual practice, and shall produce evidence of having done some original and valuable research work, or of having otherwise contributed to the advancement of the industry in which they are engaged. The Siemens Medal, founded by Lady Siemens in memory or her husband, the late Sir William Siemens, LL.D., F.R.S., will be annually awarded to the student of greatest merit in the department of electrical engineering.

The professors in charge of the several departments are :—Chemistry : Professor H. E. Armstrong, Ph.D., F.R.S. ; Engineering: Professor W. C. Unwin, B.Sc., M. Inst. C.E. ; Mechanics and Mathematics : Professor O. Henrici, Ph.D., F.R.S. ; Physics: Professor W. E. Ayrton, F.R.S., A.M. Inst. C.E.

The following are the particulars of the entrance or matriculation examination which candidates who desire to qualify for the diploma will be required to pass :—

1. Mathematics and Mechanics.—*Arithmetic* : The ordinary rules of arithmetic, decimal fractions and calculations with them ; extraction of square root ; use of logarithmic tables. Special value will be attached to exact calculations with decimals, especially by abridged methods. —*Algebra* : The ordinary rules of algebra; determination of common factors. Simple equations, with one or more unknown quantities. The elements of permutations and combinations ; quadratic equations ; arithmetical and geometrical progression ; notation and use of indices and logarithms.—*Geometry*: The first four books of Euclid's "Elements" or the subjects thereof; the theory of similar figures (Eucl., bk. VI.) ; planes and lines in space, their intersection and the angles they form with one another. —*Trigonometry* : The measurement of angles ; the definitions of trigonometrical ratios and their relations ; the elementary formulæ connecting the trigonometrical ratios of two or more angles ; the solutions of plane triangles, including the determination of their areas. Determination of heights and distances. *Mechanics* : Motion of a point ; velocity and acceleration, their units ; their composition, their moments. Quantity of matter and quantity of motion ; inertia, momentum. Mass, force, weight ; their measures. Moment of force and of momentum. Rectilinear motion under the action of gravity. Work and energy ; their units. Composition and resolution of forces at a point and in a plane ; equilibrium of forces at a point and in a plane. Special importance will be attached to clearness in the conception of mechanical quantities.

2. Mechanical Drawing.—*Plane Geometry* : Construction of scales. Reduction of polygons to triangles. Drawing circular arcs to satisfy given conditions. Drawing of geometrical patterns and figures consisting of circular arcs. *Descriptive Geometry* : Problems on the representation of lines in space by projections on given rectangular planes. Representation of simple solids in orthographic projection. Developments of the cone and cylinder. Drawing a helix on a cylinder. Sections of simple solids. Simple problems in isometric projection. *Machine Drawing* : Drawing portions of a machine to scale, in plan and elevation, from rough partly dimensioned sketches.

3. Physics.—The examination, which will consist partly of a paper of questions and partly of experimental work, will comprise the following subjects :—1. Density and its measurement ; 2. Modes of measuring the pressure of liquids and gases ; 3. The change of volume of a gas with changes of pressure and temperature ; 4. Boiling points and their measurement ; 5. Latent heat and specific heat ; 6. Mechanical equivalent of heat ; 7. Electric units ; 8. The modes of measuring electric currents ; 9. Galvanometric method of measuring the electromotive forces of batteries ; 10. Various methods of measuring the resistances of wires and batteries ; 11. The simpler laws of electrolysis ; 12. The magnetic moment of a magnet and some mode of measuring it ; 13. The laws of reflection, refraction, and dispersion of light ; 14. The focal length of mirrors and lenses ; 15. Formation of images. The practical examination will be held in subjects 1, 5, 6, 9, 10, 11, and 14.

4. Chemistry.—The composition of air, how it is determined qualitatively ; the properties of the constituents of air. The composition of water, how it is determined qualitatively and quantitatively ; the properties of water as contrasted with that of its components. The nature of elements and compounds. The use of symbols in expressing chemical change. The chief properties of the commoner elements. The oxides of the commoner elements ; the compounds which they form with water (acids and alkalies), and with one another (salts) ; positive and negative simple and compound radicles. The changes in volume in reactions in which gases take part. The nature of the phenomena of combustion ; the heat of combustion of carbon and of the combustible gases. The practical examination will comprise very simple exercises in quantitative analysis, such as the determination by volumetric methods of alkali or acid, of silver, of iron, or of iodine, and by gravimetric methods of silver, of calcium, of chlorine, or of carbon dioxide ; in the preparation of crystalline salts, and in the fitting up of apparatus for preparing gases, &c.

5. French or German.—Ability to translate at sight an easy passage from French or German into English. At the first examination, to be held in December, 1884, candidates who show special merit, but who may not be qualified in all the above subjects, will be recommended for admission.

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THE BRITISH ASSOCIATION MEETING AT MONTREAL.

Sir Frederick Bramwell, F.R.S., delivered the following presidential address to the Mechanical Section of the British Association:—

At our Jubilee meeting at York, I called the attention of the section to the fact that in 1831, when the Association first met in that city, they arrived there laboriously by the stage coach, and that practically the Manchester and Liverpool, the Stockton and Darlington, and some few others, were the only railways then in existence. I also called their attention to the fact that in 1831 there were but very few steamers. I find the total number registered in the United Kingdom in that year was only 447. If under this condition of things the proposition had been made in 1832 at Oxford, as it was made in 1882 at Southampton, that the next meeting but one of the Association should take place in Montreal, the extreme probability is that the proposer would have been safely lodged in a lunatic asylum, for suggesting that that which might have involved a six weeks' voyage out, and a four weeks' voyage back, could ever be seriously entertained. Further, to give once more the hackneyed quotation, some few years after this, *i.e.*, in 1836, Dr. Lardner established to his own satisfaction conclusively that no vessel could ever steam across the Atlantic the whole way. A striking instance of the mistakes made by scientific speculation; a branch of science widely differing in the value of its results from those branches which deal with absolute demonstration. Undeterred, however, by such adverse opinion, the engineers "kept on pegging away," experimenting, improving, and progressing, until the scientific speculation was met with the hard fact of the Atlantic voyage steamed the whole way by the "Sirius" and by the "Great Western" in 1838. The impossible was proved to be the possible, and from that day to this the advancement of steam ocean navigation has continued. The six weeks' voyage, sailing westward, of the year 1831, has become converted into but little over six days. And thus it is that that which would have been a mad proposition in the year 1832, became a perfectly rational one in 1882; and the deliberations of the general committee on the proposition were not directed as to whether it would be possible to convey the members with certainty, expedition, and economy across the Atlantic, but as to whether it was expedient or not on general grounds to hold for the first time a meeting of the British Association elsewhere than in some city of the United Kingdom. I say again that the possibility of such a meeting is absolutely due to the engineer, and that therefore, on this ground, the present is an appropriate occasion to magnify G, the Mechanical Section of this Association. It is true that the man who looks only at that which is on the surface may say, "You arrogate too much to yourselves. You ignore—to which I say Heaven forbid!—the skill and daring of your sailors. You ignore commercial enterprise. You ignore the development of iron and steel manufacture, which have enabled you to build the steamers of the present day. You ignore the increased output of the best steam coal in the world, and you attribute the whole result to the engineer." Such an objector would be in the condition of that man who, in answer to George Stephenson's question, "What is causing that railway train to move?" said, "Why, I suppose the coal that is burning in the locomotive;" and who was met by that grand and comprehensive answer, that it was the "Sun," for the coals were a consequence, and not a first cause. Similarly I venture to say that the mechanical engineer may lay claim to be the central source which has vivified and given rise to the improvements in the manufacture of iron and steel, in the construction of engines, and in the development of our collieries. There are those I know who object that Section G deals too little with pure science, too much with its applications. It may be, as the members of Section G might retort, that it is possible to attend so much to pure science as to get into the unchecked region of scientific speculation, and that had the members of Section G been debarred from the application of science, the speculation of Dr. Lardner might to the present day have been accepted as fact. I have quoted it before, but it has so important a bearing on this point, and comes from a man of such high authority, that I cannot refrain from once more giving you Dr. Tyndall's views on this question. "The knowledge of nature, and the progressive mastery over the powers of nature, imply the interaction of two things—namely, thought conceived and thought executed; the conceptions of the brain, and the realisation of those conceptions by the hand. The history of the human intellect hardly furnishes a more striking illustration of this interaction of thought and fact than that furnished by the Association of Physics and Engineering. Take, for instance, the case of steam. Without knowing its properties, the thought of applying steam could not have arisen, hence the first step was physical examination. But that examination suggested practice, and the steam engine at last saw the light; thus experimental physics was the seedling from which the steam engine sprang. But the matter did not end here. The positions of debtor and creditor were soon reversed, for the stupendous operations of the steam engine forced men of thoughtful philosophic minds to inquire into the origin of the power of steam. Guess succeeded guess, inspiration succeeded inspiration; the ever present fact of our railways, and our power looms, and our steamships gave the mind no rest until it had answered the question, How are heat and steam, its instruments, related to mechanical power? Had the works of the engineer not preceded the work of the natural philosopher, this question would never have been asked with the emphasis, nor pursued with the vigour, nor answered with the success which have attended it. It was the intellectual activity excited by the work which the civil engineers of England had accomplished that gave to philosophy the theory of the conservation of energy, including the dynamical theory of heat. . . . . The engineering genius of the future is certain to derive from this theory strength and guidance. Thus necessarily has thought originated fact, and fact originated thought. In the development of science these two powers are co-equal; each in turn ceasing to be a consequence, and becoming a creative cause. The Atlantic cable also had its small beginnings in the laboratory of the physical inquirer. Here, as before, experimental physics led the way to engineering facts of astounding magnitude and skill. But here also the positions of debtor and creditor have been reversed, for the work of the engineer has caused the physical inquirer to pursue his investigations with a thoroughness and vigour, and has given to those investigations a scope and magnitude which, without the practical stimulus, would have been impossible. The consequence is that the practical realisation of sending electric messages along the bottom of the Atlantic has been an immense augmentation of our knowledge regarding electricity itself. Thus does the human intelligence oscillate between sound theory and sound practice, gaining by every contact with each an accession of strength. These two things are the soul and body of science. Sever sound theory from sound practice, and both die of atrophy. The one becomes a ghost and the other becomes a corpse." I think all men, even although they be followers of science in its purest and most abstact form, must agree that these words are words of sound sense, well worthy of being borne in mind and of being acted on, and will therefore concur in the propriety of Section G dealing with engineering subjects generally as well as with abstract mechanical science.

Section A: Mathematical and Physical Science.—The connection between this section and Section G is most intimate. With any ordinary man I should have referred, in proof of this intimate connection, to the fact that the president of A this year is a member of the Council of the Institution of Civil Engineers; but when I remind you that it is Sir William Thomson who fills this double office, you will see that no deduction such as I have hinted at can be drawn from his dual functions, because the remarkable extent and versatility of his attainments qualify him for so many offices, that the mere fact of his holding some one double position is no certain evidence of the intimate connection between the two. But setting aside this fact of the occupancy of the chair of A by a civil engineer, let us remember that the accomplished engineer of the present day must be one well grounded in thermal science, in electrical science, and for some branches of the profession in the sciences relating to the production of light, in optical science and in acoustics; while, in the other branches, meteorological science, photometrical science, and tidal laws are all important. Without a knowledge of thermal laws, the engineer engaged in the construction of heat motors, whether they be the steam engine, the gas engine, or the hot air engine, or engines depending upon the expansion and contraction under changes of temperature of fluids or of solids, will find himself groping in the dark; he will not even understand the value of his own experiments, and therefore will be unable to deduce laws from them; and if he make any progress at all, it will not guide him with certainty to further development, and it may be that he will waste time and money in the endeavour to obtain results which a knowledge of thermal science would have shown him were impossible. Furnished, however, with this knowledge, the engineer starting with the mechanical equivalent of heat, knowing the utmost that is to be attained, and starting with the knowledge of the calorific effect of different fuels, is enabled to compare the results that he obtains with the maximum, and to ascertain how far the one falls short of the other. He sees even at the present day that the difference is deplorably large, but he further sees in the case of the steam engine that which the pure scientist would not so readily appreciate, and that is how a great part of this loss is due to the inability of materials to resist temperature and pressure beyond certain comparatively low limits; and he thus perceives that unless some hitherto wholly unsuspected, and apparently impossible, improvement in these respects should be made, practically speaking, the maximum of useful effect must be far below that which pure science would say was possible. Nevertheless, he knows that within the practical limits great improvements can be made; he can draw up a debtor and creditor account, as Dr. Russell and myself have done, and as has been done by Mr. William Anderson, the engineer, in the admirable lecture he gave at the Institution of Civil Engineers in December last, "On the Generation of Steam and the Thermo-dynamic Principles Involved." Furnished with such an account, the engineer is able to say, in the language of commerce, I am debtor to the fuel for so many heat units; how, on the credit side of my account, do I discharge that debt? Usefully I have done so much work, converted that much heat into energy. Uselessly I have raised the air needed for combustion from the temperature of the atmosphere to that of the gases escaping by the chimney; and he sets himself to consider whether some portion of the heat cannot be abstracted from these gases and be transmitted to the incoming air. As was first pointed out by Mr. Anderson, he will have to say a portion of the heat has been converted into energy in displacing the atmosphere, and that, so far as the gaseous products of the coal are concerned, must, I fear, be put up with. He will say, I have allowed more air than was needed for combustion to pass through the fuel, and I did it to prevent another source of loss—the waste which occurs when the combustion is imperfect; and he will begin to direct his attention to the use of gaseous or of liquid fuel, or of solid fuel reduced to fine dust, as by Crampton's process, as in these conditions the supply may be made continuous and uniform, and the introduction of air may be easily regulated with the greatest nicety. He will say, I am obliged to put among my credits—loss of heat by convection and radiation, loss by carrying particles of water over with the steam, loss by condensation within the cylinder, loss by strangulation in valves and passages, loss by excessive friction or by leakage; and he will as steadily apply himself to the extinction or the diminution of all such causes of loss, as a prudent Chancellor of the Exchequer would watch and cut down every unproductive and unnecessary expenditure. It is due to the guidance of such considerations as these that the scientific engineer has been enabled to bring down the consumption of fuel in the steam

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engine, even in marine engines such as those which propelled the ship that brought us here, to less than one-half of that which it was but a few years back. It is true that the daily consumption may not have been reduced, that it may be even greater; but if so it arises from this, that the travelling public will have high speed, and at present the engineer, in his capacity of naval architect, has not seen how—notwithstanding the great improvements that have been made in the forms of vessels—to obtain high speed without a large expenditure of power. I anticipate from the application of thermal science to practical engineering that great results are before us in those heat motors, such as the gas engine, where the heat is developed in the engine itself. Passing away from heat motors, and considering heat as applied to metallurgy, from the time of the hot blast to the regenerative furnace, it is due to the application of science by the engineer that the economy of the hot blast was originated, and that it has been developed by the labours of Lothian Bell, Cowper, and Cochrane. Equally due to this application are the results obtained in the regenerative furnace, in the dust furnace of Crampton, and in the employment of liquid fuel, and also in operations connected with the rarer metals, the oxygen furnace and the atmospheric gas furnace, and, in its incipient stage, the electrical furnace. To a right knowledge of the laws of heat, and to their application by the engineer, must be attributed the success that has attended the air refrigerating machines, by the aid of which fresh meat is at the end of a long voyage delivered in a perfect condition; and to this application we owe the economic distillation of sea water by repeated ebullitions and condensations at successively decreasing temperatures, thus converting the brine that caused the Ancient Mariner to exclaim, "Water, water everywhere, nor any drop to drink," into the purest of potable waters, and thereby rendering the sailor independent of fresh water storage. With respect to the application by the engineer of electrical science, it is within the present generation that electricity has passed from the state of a somewhat neglected scientific abstraction into practical use:—First, by the establishment of the land telegraph, then by the development into the submarine cable, by means of which any one of us visitors here in Canada may be in instant communication with his own country, and may be so without a selfish exclusive occupation of the cable, for once more the application of science has solved that apparently impossible problem of employing a single wire to be at one and the same time the transmitter of multiple electric massages, and messages in opposite directions. Then, thanks to the application of Faraday's great discovery of induced electricity, there has been, during the last quarter of a century, the progressive development of the dynamo machine, whereby the energy of ordinary motors, such as steam engines, is converted into electrical energy, competent to deposit metals, to—as has already been said—fuse them, to light not only isolated buildings, but extensive areas of towns and cities, and to transmit power to a distance, whether for manufacturing purposes or for the railway or tramcar; and thus the miracle is performed of converting a waterfall into a source of light, as at Sir William Armstrong's house, or into the origin of power for a railway, as at the Giant's Causeway. To the application of electrical science is due the self-exciting of the dynamos and the construction of secondary batteries, enabling a development of electricity to be continued for many hours. In the United Kingdom, general electric lighting—that is to say, the lighting of large sections of a town from a central station—has been stopped by the most unwise, because most unjust, conditions imposed by the Government General Electric Lighting Act of 1882. A new and meritorious industry, which should have been granted the same privileges as are accorded to other industrial undertakings needing parliamentary powers, was subjected to this most unjust condition: that at the end of twenty-one years the public authority of the town or place lighted should have the option of buying the undertaking for the then value of the mere materials, and that if the authority did not choose to purchase—for it was not bound to buy—at every subsequent five-year period this option should re-arise; that is to say, that a new undertaking, which would require years for its general acceptance—for the public is slow to take up a novelty—was, after the experimental and non-paying stage had been passed, to be practically forthwith taken away for a mere fraction of the capital that had been outlaid if the undertaking paid, but was not to be taken away if it did not pay. Such, in spite of the teaching of Section F, is the condition to which our Government has arrived in respect of economic science. The next electrical matter I have to touch upon, that of the telephone and microphone, with which will for ever be associated the names of Graham-Bell, Edison, and Hughes, has, as regards the public use of the telephone, been all but similarly treated in the United Kingdom. It has been declared to be within the telegraphic monopoly given by Parliament to the Post Office nine years before the telephone was invented, and the power to use it depends entirely upon the grace and favour of the Post Office, a grace and favour not always accorded; and even when accorded, coupled with limitations as to distance, and coupled with a condition of payment of 10 per cent. of the gross receipts by the companies to the Post Office as a royalty; and all this because Government has become a trader in electrical intelligence, and fears the competition of the telephone with its telegraphs. No one in the ship-loving countries of England, Canada, and the United States can refrain from feeling the warmest interest in all connected with navigation, and we know how frequently, alas! the prosperous voyage across the wide and fathomless ocean ends in shipwreck and disaster when the wished-for shore is approached, and when the sea is comparatively shallow. Except for the chance of collision, there is, in a staunch ship, little danger in the open ocean, but on nearing the shore, not only is the liability to collision increased, but shoals and sunken rocks render navigation perilous, and it is on the excellence of the lighthouses and lightships that—coupled with soundings—the sailor relies. These structures and appliances are confided to the engineer, and to be efficient they require him to be able to apply the teachings of Section A in optical science, and in the case of fogs, or as regards buoys at night time, the science of sound. I parenthetically alluded to soundings as one—indeed, a principal one—of the safeguards of ships when approaching shore. It is important in these days of high speeds that these should be made with ease and without the necessity of stopping the ship, or even of diminishing its velocity. Sir William Thomson, by the application of the science of pneumatics, has enabled this to be done. Again, most important is it that the compass, midst all the difficulties attendant upon its being situated on an iron or steel structure, should be trustworthy. And here Sir William has applied the science of magnetism in his improved compass to the practical purposes of navigation. To go to another important branch of engineering—water supply. The engineer dealing with a district to be fed from the surface will find himself very deficient if he have not the power of applying the science of meteorology to the work that he has in hand; he must know, not the average rainfall, for that is of but little use to him, but the maximum, and most important of all, the minimum rainfall over a consecutive period of years; the maximum so that he may provide sufficient channels and by-washes for floods; the minimum so as to provide sufficient storage. He must know what are the losses by evaporation, what are the chances of frost interfering with his filters and with his distributive plant. Coming to the mathematical side of Section A—whether we consider the naval architect preparing his design of a vessel to cleave the waves with the least resistance at the highest speed, or whether we consider the unparalleled series of experiments of that most able Associate of Naval Architects, the late William Froude, carried out as they were by means of models which were admirable in their material, their mode of manufacture with absolute accuracy to the desired shape, and their mode of traction and of record, we must see that both architect and experimenter should be able to apply mathematical science to their work, and that it is in the highest degree desirable that they should possess, as Froude did, those most excellent gifts, science and practical knowledge. Again, the mathematical side of Section A has to be applied by engineers when considering the strength and proportion of boilers, ships, bridges, girders, viaducts, retaining walls, and in short the whole of the work with which an engineer is entrusted. Notable instances of great bridges will occur to all our minds, especially meeting as we are in this continent of grand streams, Eads' St. Louis Bridge, Roebling's Niagara Bridge, and his and his sons' East River Bridge, Gzowski's International Bridge, and going back to our own land, Fowler and Baker's Bridge over the Forth.

Passing from Section A to Section B, there is evidently so much overlapping of these sections that a good deal that I have said in reference to Section A might properly have been reserved for Section B. The preparation from the ore of the various metals is in truth a branch of engineering; but to enable this to be accomplished with certainty, with economy, involving the not throwing away of that which is called the waste product, but which is frequently a valuable material, it is essential that the engineer and the chemist should either be combined in one and the same person, or should go hand in hand. In the manufacture of pig iron it is absolutely necessary that the chemical constituents of the ore, the fuel, and the flux should be thoroughly understood, and that the excellence of the process followed should be tested by an analysis of the slag. For want of this chemical knowledge thousands upon thousands of tons of bad pig iron have been made, and thousands upon thousands of tons were formerly left in the issuing slag. Similar remarks apply to the production of lead and of copper from the ores, and still more do they apply to that great metallurgical manufacture of the last few years—steel. In the outset steel was distrusted because of the uncertainty of its behaviour, but the application of chemical science now enables the manufacturer to produce with precision the material required to fulfil the physical tests imposed by the engineer. Reverting to the water engineer, the chemist, and the microscopist have their sciences applied to ascertain the purity of the intended source, and as in the case of Clark's beautiful process, by the application of chemistry, water, owing its hardness to that common cause, carbonate of lime, is rendered as soft as the water from the mountain lake. Taking that other branch of engineering commonly coupled with water, viz., the supply of gas, the engineer is helpless without the appplication of chemistry. From the examination of the coal to be used to the testing of the gas to be supplied there is not one stage where chemical science is not necessary. The consumer requires gas which shall be as nearly as possible a pure hydro-carbon of high illuminating power, and it might well have been that a person to whom was delivered the crude gas as it issued from the retort would have said, "Certain things may be separated out more or less, but to practice on the wholesale scale the delicate operations which will be needed to cleanse the illuminating gas from its multifarious accompanying impurities is a hopeless undertaking, and must be so if for no other reason than this—the excessive cost that would be entailed." But what are the facts? Although I for one do not like to sit in a room where gas is burnt, unless special provision is made for taking away the products of combustion, the engineer of the present day, thanks to the application of chemical science, delivers gas to the consumer in a state of comparative purity—although it may have been made from impure coal—which but a few years ago would have been deemed impossible; and so far is this improvement from being attended with extra cost, that the residual products not now uncommonly all but pay the whole cost of the coal, and in some rare instances even leave a slight profit to go towards the charge for labour. Again, it is by the application of chemical science in the dynamite and gun-cotton of the present day that the engineer is enabled to prepare submarine foundations, to blast away shoals, and to drive tunnels through rock of a character that cannot be dealt with by mere cutting machines. Equally to the application of chemistry is it due that there are hopes, by the employment of lime cartridges, of breaking down coal without that risk of igniting fire-damp which is attendant upon the use of gunpowder. I need hardly observe that much more might most pertinently be said on the way in which

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the engineer applies chemical science. In fact, those ways are so multifarious, that a volume might be written upon them, but I must pass on and ask you to consider how the engineer applies geological science, the science treated by Section C. I have already spoken of the engineer supplying towns by water collected from the surface; even he, however, must have a knowledge of geology, for without it he will not know what places are apt for the huge reservoirs he constructs, nor where he can in safety make his enormous embankments. In this continent of vast lakes one feels it must excite a sensation of the ridiculous when a Welsh lake is spoken of, but I must ask you to believe you are in Lilliput, and to imagine that the "Bala Pond" of eleven hundred acres in extent is really "Bala Lake," as it is called. Within a few miles of that, our friends at the other end of the Atlantic steam ferry, the inhabitants of Liverpool, are now constructing, under the engineering and advice of Mr. Hawksley, a waterworks which will involve the formation, I believe one may safely say the reformation of a lake practically the same area as that of Bala, of some 80ft. in depth, and containing between the overflow and the point of lowest discharge nearly twelve thousand million gallons. This lake will be made by the throwing from side to side of the valley of a solid stone bank, 100ft. above the ground, 140ft. above the deepest part of the foundations, and 113ft. thick at its thickest part. Contrasted with Lake Superior this new lake will be small, a thing demanding a microscope even, but the bursting of the wall would liberate a body of water sufficient to carry death and ruin throughout a considerable district. It is therefore in the highest degree important that whether he be constructing the solid stone wall, or the more common earthen embankment with a puddle trench, the engineer should so apply geological science as to ensure the safety of his work. But in those cases where the waterworks engineer has to derive the supply from underground sources the application of this science is still more necessary; he must know whether he is likely to find a water-bearing stratification at all—if so, where it receives the rain from heaven, and the extent of the area which receives it; in what direction the water travels through it, what is the varying height of water in the different parts of the stratification giving the "head" to produce that travel; how far this height is likely to be affected by the pumping of the desired quantity; whether, if near the outflow into the sea, the pumping is likely to reverse the direction of the current, and to bring back brackish water, and whether the rocks are of such a character as to be liable to yield a water impregnated with iron or with lime, and whether these water-bearing rocks are accessible from the surface without the execution of costly and laborious work in passing through over-lying stratifications of an unfit or it may be even of a dangerous character. It need hardly be said that the engineer when engaged in metalliferous mining, or in the extraction of coal or of petroleum, unless he applies the science of Section C, is but a haphazard explorer whose work is more likely to end in disaster than in success. Again, the engineer when laying out a railway, has to consider the geological features of the country in determining the angles of his cuttings, and to determine where it becomes more economical to tunnel than to cut. Indeed, without the application of that science to engineering there are some enterprises on the feasibility of which the engineer would not be able to pronounce an opinion—a notable instance, the Channel Tunnel. The engineers, of whom I am one, said there is a material, the compact non-water-bearing grey chalk, which we have at a convenient depth on the English side, and is of all materials the most suitable; if that exist the whole way across success is certain. Then came geological science, and that told the engineer that in France the same material existed; that it existed in the same position in relation to other stratifications as it existed in England; that the line of outcrop of the gault lying below it had been checked across; and that taken together, these indications enabled a confident opinion to be expressed that it was all but certain this grey chalk stratification did prevail from side to side. The engineer believed it, an intelligent section of the public believed it, and came forward with their money; large sums were expended in England and in France on the faith of the repeated declaration of the English Government—of both sides of politics—that so long as the nation was not called on to contribute towards the cost of the work, it would hail with satisfaction the improved means of communication between England and the Continent; the experimental works were carried on from both sides with the happiest results, and then, when success appeared certain, the whole work was stopped by the incredible suggestion that in the event of a war the soldiers of England, and the science of England, could not defend a couple of rat-holes—holes 14ft. in diameter and 20 miles long, situated far below the surface of the sea, having a rapid dip from the shore to a low point, gradually rising from there to the centre of the length of the tunnel, so that the English end could be flooded with sea-water in twenty-five minutes up to the soffit of the arch at the dip; and in consequence of this incredible and most-to-be-ashamed-of scare it is due that one of the finest instances of civil engineering work in connection with the science of geology, and, as I believe, one of the most useful works that has ever been proposed, has been put a stop to. To come to Section D, the botanical side of it is interesting to the engineer as instructing him in the locality and quality of the various woods that he occasionally uses in his work. With regard to that most important part of the work of D which relates to "germs" and their influence upon health, the engineer deals with it thus far; he bears in mind that the water supply must be pure, and that the building must be ventilated, and that excreta must be removed without causing contamination; thus the waterworks engineer, the warming and ventilating engineer, the sewage engineer can—and do—all of them profit by the labours of Section D, and can by their works assist in giving practical value to the pure science of that section.

Section E, Geography.—Probably in these days, when our kingdom at home and the old countries near us are all but full of the works of the engineer, there are few who take a greater interest in geography than he does, and I am quite sure there are none who make a more useful application of geographical knowledge for the benefit of mankind at large than does the engineer. Almost at the outset of this address I claimed to magnify Section G, on the ground that without the aid of its members we should not have had that practical lesson in geography which we have received by our visit here, a lesson that no doubt will be continued and amplified by many of us before we return to our homes. Whether it be by the ocean steamer or by the railway train, the enterprising geographical explorer is carried to or through countries which now, thanks to the engineer, are well known and settled, up to the beginning of the unknown and not settled; and thus his labours are lightened, he consumes his energies only upon his true work, brings back his report, which is, as I have said, studied by the engineer, with a view to still further development, and thus turn by turn the geographer and the engineer carry civilisation over the face of the world. Now to come to Section F, which treats of Economic Science. The matters with which this section deals—birth-rate, death-rate, the increase or diminution of populations, the development of particular industries in different localities, the varying rates of wages, the extent and nature of taxation, the cost of production, the cost of transport, the statistics of railway and marine disasters, the consumption of fuel, and many matters which come within the purview of F, are of importance to the engineer. Guided by the information given him by the labours of this section, he comes to the conclusion that a work having a particular object in view should or should not be undertaken. With the information derived from the past he judges of the future; he sees what provision should be made for prospective increase of population or of industries; he sees the chances of the commercial success of an undertaking or of its failure, and he advises accordingly. I do not propose to say anything about Section H, for I have dealt with it as being still included within D. I trust I have now established the proposition with which I set out, viz., that not only is Section G the section of Mechanical Science, but it is emphatically the section of all others that applies in engineering to the uses of man the several sciences appertaining to the other sections, an application most important in the progress of the world, and an application not to be lightly regarded, even by the strictest votaries of pure science, for it would be in vain to hope that pure science would continue to be pursued if from time to time its discoveries were not brought into practical use.

SELECTED CORRESPONDENCE.

ELECTRIC LIGHTING

The following letter appeared in *The Times* of Sept. 10th, and is a continuation of the Correspondence which had previously appeared, and which we have reprinted:—

"SIR: Referring to the letters of your correspondents 'A. S.' and 'G.' on this subject, it will be opportune, now that so many of the provisional orders have been revoked, to endeavour to ascertain why the legislation which was ostensibly designed to facilitate and regulate the supply of electricity has so completely failed in its purpose, and, with the knowledge now possessed, to see whether the delay in the application of electricity to house-to-house lighting has been due to legislation or to causes attributable to the companies.

"The march of events in regard to every new matter of general and public importance has shown that hitherto any innovation has had in its initial stages to push its way as best it could, and it has only been gradually, as the demand has exceeded the means of supply, or the opposition of vested interests has proved too strong, that the Legislature has interfered to mediate between the opposed interests. But for electric lighting the extraordinary destiny has been reserved of being smothered by kindness in its infancy. So long as the industry was free and untrammelled and until the demand for legislation in electrical matters arose it prospered, and, although the advance was not comparable with that made in America, yet by working in harmony with local authorities good and steady progress was being made in different parts of the country, and there was every prospect of electricity as a lighting power being generally adopted in the course of a few years; but, as stated by Sir Frederick Bramwell at the meeting of the British Association last week, 'the lighting of large sections of a town from a central station has been stopped by the most unwise, because most unjust, conditions imposed by the General Electric Lighting Act, 1882.' I do not mean that this effect was produced at once, perhaps it would have been better if it had been, for the evil of the repressive conditions in the Act would then have been better appreciated, much money would have been saved, and the Act no doubt would have been speedily amended.

"Earnest and legitimate attempts, however, were made to work in accordance with its provisions, but with the exception of a few notable and creditable instances they have all practically failed, and it has now become evident to the companies who boldly and enthusiastically undertook to develop this new industry that there is but little to be done against such severe odds.

"A consideration of the following points will, I think, make it manifest that if the object of the Legislature had been not to facilitate and encourage the development of a new industry, but to dishearten and throttle it as an unwelcome intruder, this object could not have been better accomplished than by the onerous conditions imposed upon the undertakers by the Act and by the spirit in which the Board of Trade have framed the provisional orders.

"There is one clause which in itself is quite sufficient to condemn the Act as unjust and unbusinesslike—viz., the one by which local authorities can within six months after the expiration of 21 years, or such shorter period as may be specified in the provisional order, require the contractors to hand over to them their business, upon terms of paying the then value

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of all lands, buildings, works, material, and plant, 'without any addition in respect of compulsory purchase, or of goodwill, or of any profits which may or might have been or be made from the undertakings, or of any similar considerations.'

"The local authorities are not even deprived of this extraordinary privilege if at the end of 21 years they see no advantage in taking over the undertaking, but they have the opportunity to exercise this right to appropriate the successful results of private enterprise after the expiration of every subsequent period of seven years; and this consequently makes it incumbent upon the contractors to earn sufficient profits during the limited term of their proprietorship to compensate for all the initial losses which are inseperable from a new enterprise, including the not inconsiderable cost of obtaining the order, and to provide for the difference (a very uncertain factor) between the original cost of the properties and their fair market price at the time of purchase by the local authorities, 'due regard being paid to the state of repair thereof and the suitability of the same to the purposes of the undertaking.' The undertakers are allowed no option in the matter but to cover their expenses as quickly as they can, and are thus precluded from taking a broad view of the business by charging low rates in order to compete with the gas companies, but are constrained to charge the maximum rates allowed by the order, for if they failed to accomplish the return of their money with interest within the time stated, they must inevitably suffer enormous pecuniary loss, because, however remunerative the concern may have become by the end of 21 years, they can be required to hand it over to the community on terms which can only be described as confiscatory, just as if they had been actuated in the work solely and simply by philanthropic motives.

"The Act assumes that two years are required to carry out the necessary works of development, so that even if the extreme period is specified, there are only 19 years in which the undertakers have a chance of recouping themselves; but in some of the provisional orders which have been granted, and subsequently abandoned in spite of the large sums spent in obtaining them, the tenure of the undertakers is limited to 15 years. Could it reasonably be expected that any body of shareholders would assent to the sinking of their capital for the purpose of supplying the electric light under the Act when once the full purport of this section was recognised? While there is no inducement for capitalists to invest money in such an enterprise at the outset, there is far less reason for expecting them to do so as the period of compulsory sale draws nearer, as the only security which the undertakers would be able to offer, should they require additional funds for the legitimate extension of a profitable business, would be a mortgage on the purchase money, payable by the local authorities in the event of their taking over the undertaking.

"The Board of Trade seem to have recognised this, for the provisional orders provide that sufficient capital shall be set aside for the purposes of the undertaking before any work can be commenced, and that one-half of such amount shall be deposited or secured to their satisfaction. These conditions are supplemented by several stringent regulations as to time, &c., the neglect of which may involve the revocation of the order 'on such terms as the Board of Trade may think just.'

"The Act was a panic Act, and was carried through by representations that the public would be left at the mercy of an enormous monopoly, similar to, if not greater than, those possessed by the gas and water companies. It should be remembered, however, that these monopolies were only granted as inducements to capitalists to embark money in enterprises to supply the public largely and cheaply with the commodities required. In the opinion of many the same results would have been obtained at greater advantages to the public had free trade been allowed, and all that electric lighting contractors ask is to work on the principle of free trade, subject to a maximum charge and to reasonable control by local authorities in consideration of the use of the streets and pavements; and it should be remembered that the disturbance to the streets in the case of the supply of electric light and power is infinitely less than that rendered necessary by the supply of gas and water.

"This leads up to the argument which is sometimes advanced that the section by which the proprietary rights of the initiating company are limited to a term of years has a precedent in the Tramways Act, and it is argued that because that Act has not frustrated the progress of tramway enterprise, the later Act is not likely to obstruct the advance of electric lighting. Bnt in drawing this analogy the fact is evidently lost sight of that the Tramways Act specially stipulates that local authorities shall not themselves work the tramways after they have acquired them, but shall entrust the administration of the same to contractors. This salutary provision is altogether omitted from the Electric Lighting Act, and it should further be remembered that the promoters of tramways are granted the right to use, free of rent, and to the exclusion of all tramway competitors, about two acres of public land for every mile of double tramway. This is a concession which compensates for a great deal, and is worth paying for, seeing that it renders unnecessary the purchase of land, which in railway and other undertakings forms the main item of capital expenditure; but the provisional orders under the Electric Lighting Act grant no such monopoly, and confer no rights except those of forming conduits under the pavements of the public streets.

"It will be seen, therefore, that the electric lighting companies have been treated with the most exceptional severity. They are too much at the mercy of both the Board of Trade and the local authorities, and many of the conditions imposed upon them are violations of those commercial and economical principles which lie at the root of all enterprise and progress. For instance, although the contractors are bound to supply, within a given area, electricity to any inhabitant who may demand it, there is no provision enabling them to acquire compulsorily the land which they require to carry out their engagements. Although the Lands Clauses Acts are to a certain extent embodied in the Electric Lighting Act, the enactments with respect to the purchase and taking of lands otherwise than by agreement are carefully eliminated, and yet without these rights electric lighting companies, any more than railway companies, are unable to carry out their undertakings.

"Many of the other clauses are either inoperative or mischievous. No one is likely to deny that the Board of Trade is right in taking due precautions for the public safety, similar, say, to the restrictions it imposes upon railway companies in regard to level crossings, to the speed of trains round curves, and the condition of the rolling stock and permanent way; but to limit the electromotive force or pressure of electricity in well insulated and protected leads in or under the streets to below what would, under any conditions, be unsafe, is as absurd as to limit the speed of trains along a well laid and protected line of railway to 15 miles an hour. Many of the other rules laid down by the Board of Trade are of such a character as to render economical house-to-house lighting on an extensive scale almost impossible.

"Nevertheless, there are companies who will be able, it is hoped, to persevere in their earnest endeavours to supply the public with electricity from central stations at a reasonable price, in the hope that by demonstrating the enormous advantages of the electric light over all other illuminants public opinion may be aroused on the subject, and that the Act may be amended and the Board of Trade convinced that the best way to facilitate and regulate the supply of electricity is to allow the electric lighting companies to make a start, and to ascertain by practical experience what the needed conditions are for securing alike the welfare of the public and the interests of the undertakers. This is a question more for the public than for the companies, for the latter have for some time to come a very wide field in providing electric lighting plant for theatres, factories, ships, railway stations and trains, and for those occupiers of dwelling houses who are prepared to find their own motive power rather than be deprived of the advantages of the new light; while those who, appreciating the evidences of these isolated installations as to the purity, safety, and cleanliness of electricity, are waiting to be supplied with the electric light, but not the plant, will, I trust, find in this letter a sufficient reply to the very reasonable inquiry—'Why does not electric lighting go ahead?'—I am, Sir, your obedient servant, "E. G."

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Sept. 10.		Business Done Week Ending Sept. 10. Highest.	Lowest.
Anglo-American	30,	31	30¾	—
Do. Preferred	54,	55	55½	54¾
Do. Deferred	6½,	7	7	6¾
Brazilian Submarine	11,	11½	11	10¾
Cuba	10¾,	11¼	11⅛	—
Do. Preference	16½,	17½	17⅜	—
Direct Spanish	4,	4½	4	—
Do. Preference	14½,	15½	—	—
Direct United States Cable	9⅞,	10⅛	10 1-16	9 15-16
Eastern Telegraph	11⅜,	11⅝	11½	11¼
Do. 6 per Cent. Preference	13¼,	13¾	13⅝	13¼
Do. 5 per Cent. Debentures, 1899	103,	106	105½	104
Eastern Extension	11½,	11¾	11¾	11 9-16
German Union	9½,	10	9⅞	—
Globe Telegraph and Trust	6⅝,	6⅞	6 13-16	6⅝
Do. Preference	12½,	12¾	12¾	12⅝
Great Northern	13½,	13¾	13⅝	13¼
Indo-European	31,	32	32	—
Reuter's	8,	8½	—	—
Submarine	165,	175	168½	—
West India and Panama	⅞,	1⅛	—	—
Do. 1st Preference	7½,	7¾	7½	7 5-16
Western Brazilian	6⅝,	6⅞	6 15-16	6⅝
Western Union 7 per Cent. 1st Mortgage	123,	125	—	—
Do. 6 per Cent. Sterling Bonds	100,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	¼,	⅜	5-16	—
Oriental	⅛,	⅜	—	—
United Telephone	12,	12½	12 9-16	12

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1½,	1¾	1¾	—
Do. (fully paid)	2¾,	3¼	—	—
Hammond Light (£3 15s. paid)	¼,	½	⅜	—
Swan	—	—	1-16	—
Maxim-Weston	1-16,	3-16	—	—

MISCELLANEOUS.

Telegraph Construction	32½,	33½	33	32¾
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23¾	23

TRAFFIC RECEIPTS FOR AUGUST, 1884.

Companies.	Aug., 1884.	Aug., 1883.	Increase.	Decrease.
Cuba Submarine	2,375	2,315	60	—
Direct Spanish Telegraph	1,173	1,547	—	374
Eastern Extension	35,967	38,126	—	2,159
Eastern Telegraph	45,829	44,937	892	—
Great Northern	26,800	—	—	—
West Coast of America	3,690	—	—	—

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NOTES.

CARRE'S CARBONS.—We hear that Messrs. Thompson, Dowsing, and Rew have been appointed sole agents for Carré's improved carbons, manufactured by M. Lévy, of Paris.

ELECTRIC LIGHT AT HARROGATE.—The Corporation have made an arrangement with a firm of electricians at Leeds, who are lighting the Spa, to illuminate the town for three months at a cost of £50, by way of experiment.

FOUNDER OF THE "SCIENTIFIC AMERICAN."—Rufus Porter, who brought out the *Scientific American* in 1845, died recently at the age of 92 years. He was a man of fertile invention and great versatility of genius.

NEW CABLE SHIP.—The steamer "Mackay Bennett" was launched on Thursday from Messrs. Elders' yard. The vessel is intended for the Commercial Cable Company for holding cables, her capacity for which is 27,000 cubic feet.

CHANGE OF ADDRESS.—Messrs. F. Young and Co., telephone, telegraph, and bell-case makers, have removed their offices to 11 and 10, Dean-street, Holborn, W.C., but are still carrying on their steam works at 11, Clerkenwell-green, E.C., as heretofore.

ELECTRIC LIGHT AT CHICAGO.—A local company has constructed a large central station on the west side, for illuminating the business houses in the vicinity of Madison and Halstead streets. The Van Depoele system is used, and 150 lights are probably now shown.

ELECTRIC LIGHT AT CARDIFF.—At a recent meeting of the Lighting Committee of the Cardiff Corporation, the offer made by the Great Western Electric Light and Power Company to illuminate St. Mary-street with a number of incandescent lamps for £167 a year was accepted.

ELECTRICITY AND SEWING MACHINES.—The American Electric and Illuminating Company proposes to fit up a building with improved sewing machines, each running with a Stockwell electric motor, to be let to women at the nominal price of 20 to 25 cents (1s. or less) a day.

ELECTRIC LIGHT AT NEW ALBANY.—The proprietors of the large woollen mills have contracted with the Cleveland, U.S., Brush Company to supply 275 incandescent lamps of 20 candle-power, to be run from a Brush dynamo direct. The De Pauw Glass Works are using Brush arc lights.

ELECTRIC LIGHT AT BRADFORD.—At a recent meeting of the Bradford Town Council the Gas Supply Committee's minutes were adopted, with the exception of that part relating to the electric lighting of a portion of Allerton, which was referred back to the committee for further consideration.

BELLATI'S AUTOMATIC REGULATOR.—At the Turin Exhibition is shown the automatic electrical regulator devised by Bellati, of Padua, in which a mechanical thermometer, interrupting and concentrating the circuit, causes the intensity of the flame to vary, so that the temperature can never exceed, or fall below, certain limits.

TELEPHONE RATES IN BELGIUM.—As soon as the arrangements are complete the fee for telephoning between Brussels and the provinces over the telegraph wires by the Van Rysselberghe system will be 1fr. for five and 1½fr. for ten minutes' conversation. The subscribers will be able to telephone directly after getting put in communication with the central office, the *employés* of which will collect the fees.

CABLE BETWEEN BRISBANE AND SAN FRANCISCO.—The proposal of an Australasian syndicate to lay an ocean cable from Brisbane to San Francisco has been favourably received by the Hawaiian Legislature, and a report in favour of granting a subsidy of 20,000dols. (£4,000) per annum for fifteen years promptly passed the third reading. This syndicate also proposes to lay a cable between California and Queensland.

WIGAN COAL AND IRON COMPANY.—An order for the lighting of the Wigan Coal and Iron Company's works has just been given to Mr. F. D'A. Goold, electrical engineer and contractor, Arcade Chambers, St. Mary's Gate, Manchester. This order is the outcome of a successful installation which our readers will remember we drew their attention to some months back. Mr. Goold is also to supply the apparatus required for lighting Westfield, Coventry.

BOOKS RECEIVED.—"Illustrations and Descriptions of Telegraphic Apparatus," by A. C. Terry and W. Finn, published by A. C. Terry, Buffalo, New York; "*Transactions* of the Institution of Civil Engineers of Ireland, forty-seventh and forty-eighth Sessions to June, 1883," Vol. XIV. This volume contains a paper by Mr. T. B. Grierson on Electric Lighting by Water Power, and a paper by Mr. J. Angelo Fahie on Magneto and Dynamo Electric Machinery.

THE EASTERN TELEGRAPH COMPANY AT THE TURIN EXHIBITION.—In a notice inserted in a publication bearing the title of *Esposizione Italiana del* 1884 *in Torino*, the ingeniere R. Sartorio expresses pleasure at welcoming this company, "the most powerful that exists," at the national show of electricity, so well represented by "Cavaliere Alfredo Eggington." He recounts the early struggles of the company, as well as its surmounting of all difficulties "with British perseverance," and by aid of the siphon recorder, which he translates *sifone annotatore*.

LOCOMOTIVE HEAD-LIGHT.—In our last issue we referred to Mr. Wooley's electric head lamp, maintained by a dynamo, worked by a separate motor with steam from the locomotive boiler. We now learn that it is intended not only to place the electric head-light in its usual position on the locomotive, but also to put another in the rear of the cab for throwing a light over the whole train, and so arranged that it can be turned to the right or left, and be made to illuminate stations and their approaches when the train is standing.

BELGIAN ARMY TELEGRAPH CORPS.—The corps of telegraphists in the Belgian Army is divided into two companies, the first of which is intended for the telegraphic service of the army in time of war, while the second, named the Compagnie des Télégraphistes de Place et d'Artificers, is intended for service in fortified places. In time of peace each company consists of a captain with an effective of 80 men, for the most part non-commissioned officers; but in time of war each company consists of 200 men, furnished by the military engineer corps and trained for telegraph service.

ELECTRIC LIGHT IN NEW YORK.—It is rumoured that the New York Steam Company intends to undertake electric lighting as well as the supply of steam for heat and power. Mr. W. C. Andrews, the president, has stated that his company hoped within a year to have every house in Fifth Avenue, from Washington-square to the Park, heated by its steam and

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lighted by Sawyer-Mann lamps, obtaining current from their dynamos. He expressed the belief that the electric light will come cheaper than gas. The company is laying down an ordinary gas pipe, which may be used for an electric wire cable, and also a steam pipe, along Fifth Avenue, from the square to the Central Park.

ELECTRIC RAILWAYS AND LIGHTING.—Plans were duly deposited with the Board seeking to confer powers on two different companies for the construction of electric railways beneath the carriage way of High Holborn. One of these schemes did not reach the stage of committee; but the London Central Electric Railway was before a Committee of the House of Commons for the greater part of a week, when, after evidence had been taken both for and against the measure, the preamble was declared not proved. As regards electric lighting, two companies obtained provisional orders, conferring parliamentary powers for public electric lighting in the district, but neither of them put those powers in force.

ELECTRIC EXHIBITION AT BOSTON.—It is proposed to hold an electrical exhibition in the building of the Massachusetts Mechanics' Association, Huntingdon-avenue, Boston, from 24th November next to 3rd January, 1885. Its object is to show the rapid advancement that has been made in electricity, its methods and appliances, and all its possibilities and probabilities. Exhibitors will have to pay an entrance fee of 10 dollars (£2 2s.) each, to cover space and power. They will be permitted to sell, but not deliver goods, during the exhibition, except by special permission. Application for space must be made by 1st November. There is an influential "advisory board." P. H. Alexander is general manager, W. S. Hill superintendent, and B. F. Porter chief clerk.

SENEGAL CABLE.—We are informed that the Silvertown Company's ss. "International" arrived at Santa Cruz de Tenerife on Monday, the 15th inst., and that on the following day she landed the Tenerife shore end of the Senegal cable in Tejita Bay. This vessel leaves Tenerife for St. Vincent and St. Jago, Cape de Verde Islands, to survey landing places on these two islands, and to sound the route between them. After completing her work between these islands she will proceed to a point off Dakar, Senegal, whence she will sound towards Tenerife. On her arrival there she will meet the ss. "Silvertown," with the deep-sea portion of the Senegal section. The "Silvertown" arrived at the India Rubber Company's moorings on Tuesday, the 16th inst., and commenced shipping Senegal cable on Thursday, the 18th.

ELECTRIC LIGHT IN CHINA.—A special correspondent at Foochow thus describes the effect produced on the natives by an electric search light from the French flagship:—"I happened to be going down to the anchorage last night in a steam launch, and just as Pagoda anchorage hove in sight the 'Volta,' the French flagship, lit her electric search lamp and threw a blinding ray on each Chinese gunboat in turn to see if they were slily slipping their anchors or rigging torpedoes. I steamed through the Chinese fleet while the search light was on them, and the effect was most ludicrous—the cries and antics of the men on board who seemed to think there was something very awful in a light so strong that their eyes could not bear to look at it. It was a curious sight seen from a little distance; the night was slightly hazy, and the ray from the lamp seemed like a gigantic wedge-shaped arm thrown out by the vessel. The 'Volta' had two torpedo boats alongside, with steam up, and all on board were moving about in an excited, restless manner."

STATISTICS OF THE BRITISH EMPIRE.—Sir R. Temple in his presidential address to the Economic Science Section of the British Association at Montreal, among other things touched upon telegraphy. He said, regarding electric telegraphs on land, that there are 86,000 miles in the British Empire, or nearly one-fifth of the sum total for the world. It is remarked that the telegraphs in Australia—26,000 miles—are exactly equal to those in the United Kingdom. But in illustration of the difference between an old and a new country there are 31,000,000 of messages yearly in the United Kingdom, and only 5,000,000 in Australia. In other words, the telegraph does six times as much in the old country as in the new. Similarly in the United States, the length of telegraph—121,000 miles—is amazing; but the messages are only 34,000,000, just in excess of those in the United Kingdom. In other words, the work is more than four times as heavy in the United Kingdom as in the United States. Besides the land telegraphs, there are submarine cables in the world with the surprising length of 105,000 miles. Of these the greater part belong to the British Empire.

ELECTRIC FILTER.—Dr. Dobell lately advised that noxious germs should be destroyed by passing an electric current through the water that contains them. A similar idea appears to have occurred to Dr. Stephen Emmens, who has devised an electric filter, consisting of a glass vessel in which are placed porous vases. These latter contain coal or spongy iron, and also carbon plates connected with the positive pole of a Leclanché battery, being kept apart by other carbon plates communicating with the negative pole. The water to be filtered flows into the porous vases, passes through the coal or spongy iron, and runs out of the containing vessel. Like Dr. Dobell, Dr. Emmens supposes that the oxygen set free destroys all the germs which might render water injurious to health. The invention is also applicable to the purification of sewage waters, in which case the filter takes the form of a conduit, divided by partitions into a series of elements, traversed in succession by the water. The electrodes are wooden cages, alternately filled with pieces of iron and coke. With this arrangement a primary battery is not necessary, for the conduit itself forms a powerful battery, the current of which is more than sufficient.—*L'Electricien.*

THE TELEPHONE AT ABERDEEN.—At a *conversazione* given by the Corporation of Aberdeen to the delegates attending the Trades Union Congress, the corridor was lighted by a Pilsen 2,000-candle lamp; and the square room was set aside for telegraphic and telephonic instruments. The latter department was in charge of Mr. John D. Millar, district manager of the National Telephone Company, Limited, who had arranged a miniature switch room, showing the whole working of a telephone exchange, and permitting the visitors to hear pianoforte music played at Ferryhill and band music from Oldmill. There was also a fire alarm which, when the temperature rises beyond a certain point, gives warning at the Post Office, and also at the owner's house. So sensitive is this appliance, that any excess of heating in a grain merchant's store is exactly indicated, and the bell continues to ring until the normal degree of temperature is restored. In a burglar alarm, direct communication is made with the police station on a door being opened after being once closed for the night, and that without the knowledge of the person opening it. Mr. Millar also showed Gower-Bell telephones of the original type, with a number of the recent improvements for the rapid transmission of telephonic messages, and also his own patented switch connection with complete telephonic apparatus.

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ELECTRIC LIGHT IN THEATRES.—We last week referred to the Paris Ambigu having been added to the list of theatres lighted by electricity; and, as this is stated to be the first complete application to a theatre in Paris, we subjoin a few particulars. The lights comprise 20 Jablochkoff candles (ten outside, one in the vestibule, two in the crush room, and seven in the auditorium) and 306 incandescent lamps (27 in the auditorium, 167 on the stage, 42 in the passages and on the staircases, and 70 in the offices and dressing rooms), besides 15 Jablochkoff candles which can be used for special effects on the stage, subject to the suppression of an equal number elsewhere. The current is supplied by self-exciting alternate-current Gramme dynamos, two of Type 1 for the Jablochkoff, and two of Type 2 for the incandescent lamps. This arrangement has been adopted to avoid total extinction in case of breakdown in either division, and because the premises do not admit of putting down spare plant. The motive power is given by a 70 h.-p. Sulzer compound engine, running at 80 revolutions a minute, and supplied by steam from two 40 h.-p. Denayer tubular boilers. The work was executed by the Société d'Eclairage Electrique, who encountered great difficulties owing to the insecure foundations and bad condition of the walls. The *Bulletin de la Compagnie Internationale des Téléphones* suggests that all the Jablochkoffs be placed in the hinder half of the auditorium, so as not to tire the eyes of spectators; and also that the globes be of a slightly yellow tint, as at the Châtelet Theatre.

ELECTRIC LIGHT AT TORONTO.—We glean from the correspondence of the New York *Electrical World* the following particulars as to the lighting of Toronto by electricity. On 26th March tenders were opened, when it was found that the Toronto Electric Light Company, using the Excelsior system, offered for 65 cents. per lamp per night, and the Canada Electric Light and Manufacturing Company, using the Van Depoele, for 62 cents. It was resolved that the two companies be invited to set up twenty-five lights each, at 62 cents. per lamp nightly, for a period of three months, the company not making the better show to withdraw. On 16th May the two companies started twenty-five lights each, which number was subsequently increased to 44. At the expiration of the contest, on 13th August, the five years' contract was entrusted to the Toronto Company. This company has now circuits of over 30 miles, and has erected a fine station, 100ft. square, with six "Excelsior" 130-light dynamos, two Armington and Sims 50 horse-power engines, one 60 horse-power Ide engine, two 100 horse-power steel boilers, and safety switches for each circuit. Additional plant was also being contracted for to enable the company to provide for all possible contingencies, and guarantee an uninterrupted service of electric light. On the other hand, the Van Depoele Company is constructing large central plant for maintaining about 200 lights, and has also undertaken the construction of an electric railway, four or five miles long, to be propelled by an electric motor on their system.

RACE BETWEEN TWO ELECTRICAL LAUNCHES.—A new electric launch, the "Australia," has just been completed and launched from the wharf of the Electrical Power Storage Company at Millwall. The hull of this launch has been built by Messrs. Forrest and Sons, to the order of Messrs. Stephens, Smith, and Co., engineers, for an Australian firm. She is of mahogany; length 25ft., beam 5ft. 7in., and she can carry sixteen persons comfortably. The motive power consists of Electrical Power Storage accumulators, placed as ballast at the bottom of the boat, and a Reckenzaun electro-motor, driving a two-bladed gun-metal screw of 18in. diameter and 11in. pitch. The Reckenzaun motor weighs 390lb., and is capable of working up to 6 horse-power mechanical, but ordinarily it will be worked at a lower rate in this boat—at the rate of 5 electrical horse-power. Weather permitting, a competitive trial trip will take place on Saturday next, at two o'clock, from Millwall to Charing Cross Pier and back to Greenwich, the competing launch being the well-known boat "Electricity," which caused some sensation when launched in September, 1882. This launch was designed at the time by Mr. A. Reckenzaun for the Storage Company. She is of iron, 25ft. long, and only 5ft. beam. A set of Electrical Power Storage accumulators supply the current to a Siemens D2 dynamo, weighing 658lb. The screw is of steel, made by Messrs. Yarrow and Co., 18in. diameter and 11in. pitch, and which screw formed a pattern for casting the one in the new launch. It will be arranged that during the trial both machines shall be supplied with the same amount of energy, viz., 3,730 watts, or 5 electrical horse-power.

EDISON ON ELECTRICAL APPLICATIONS.—The *Electrical World* is responsible for the following :—

"What is the latest thing in the application of electricity, Mr. Edison?"

"The funniest is the new process of making incandescent whisky."

"What's that?"

"Well, that is whisky, as my friend Amos Cummings would say, with the shiver taken out of it."

"How do they effect that with electricity?"

"Well, I am told they let down the incandescent light into a barrel of whisky, and in sixty-four hours they get all the flavour of old whisky. The light and heat seem to act on the fusel oil somehow. I am told they make an excellent brand of whisky out of 'rot gut.'"

"Have you tried it?"

"No."

"What is the most curious electrical phenomenon of late?"

"That is hard to say, there are so many. One of them is a live fish swimming in a tub of clean water, having swallowed a bait consisting of a little incandescent lamp. When the current is turned on, the fish is lighted up, so you can see through him and observe the circulation of the blood."

"What do you propose to show at the Philadelphia Electrical Exposition?"

"Only about ten per cent. of my stuff; but enough."

"Did you ever know of any practical use for the phonograph?"

"No, except as a curiosity. About all the colleges have them. I had to give it up for the electric light, where the field is immense."

SINGLE-FLUID BATTERY.—M. Georges Pierre writes from Poitiers to our contemporary *L'Electricien* to the effect that he has invented a single-fluid battery which he claims to be impolarisable for several days, even when short-circuited. The negative electrode is amalgamated zinc, and the liquid the white caustic potash of commerce, as usual. But the positive electrode is in the form of a flat box, of a certain thickness, perforated with rather small holes. In the thickness of this box M. Pierre places as many small iron points as possible, and it is to these that he attributes the constancy of the battery, which serves for electro-deposition and for medical purposes. At the commencement of the action there is a high E.M.F., which, however, falls somewhat in a few hours, and then remains constant for several days upon a closed circuit. The cell is only 10 by 20 centimetres (4 × 8in.), with zinc on one side

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only; but by giving it from 25 to 30 by 25 centimetres, and surrounding the zinc on both sides with two iron boxes of the same kind, a "duty" in amperes equivalent to that of a Bunsen element may be attained. The advantage of the battery is that it consumes nothing in open circuit. If the caustic potash be prepared by the user in a large cast-iron vessel, the liquid containing the potash in solution, when the solution of carbonate of potash has been treated with quicklime, has only to be concentrated to half its volume by evaporation, and then cooled, to be ready for use in this battery. The zinc may be replaced by a lead plate in the same battery. Although lead is cheaper than zinc, the difference is nearly compensated for by a lower E.M.F. The same battery may also be fitted with copper instead of zinc, when it has also a high E.M.F.; but this makes the battery unnecessarily expensive.

Music by Telephone.—Under this head we recorded last week the successful transmission of instrumental music from Brussels to Antwerp. Intelligence now reaches us of an opera played in Brussels being heard by the King and Queen of the Belgians at Ostend. Six microphones on the Van Rysselberghe systems had been placed in front of the footlights, facing the performers. Two similar instruments were also fitted, one on either side of the conductor's desk, at the height of the musical instruments in the orchestra; and for future occasions it is determined to add a double microphone in the prompter's box. All these transmitters were actuated by a single Faure accumulator, placed under the stage with the microphone coils, the latter being all mounted in quantity, and really forming but one and the same transmitting instrument. As in the case of the experiments recorded last week, the circuit was formed by one of the overhead wires of the Bell Telephone Company, leading from the central office to the northern terminus, where it joined the State Telegraph line to the Ostend Station, which was in direct communication with two Bell receiving instruments, fixed in the drawing room of the royal châlet. M. Berlin, engineer, who had directed the installation with M. Van Rysselberghe, remained at Ostend, while the latter gentleman went backwards and forwards from the Monnaie Theatre (the Brussels Opera House) to the telegraph office at the northern terminus for watching how the instruments worked. These had been placed in the theatre during the day by M. Mourlon's men in charge of the foreman, Hobé. The experiment is reported to have again succeeded beyond expectation, and on the following day M. Van Rysselberghe had the honour of being received by the Queen, who is known to be an assiduous opera-goer as well as an accomplished musician. Her Majesty spoke of having heard perfectly all the details of the first and last acts of "Faust," and made some valuable suggestions for a permanent installation.

The Telephone in Spain.—There exists at present no public telephone system in Spain, though there are municipal lines at Bilbao and Valencia, military lines at Madrid, Valencia, Saragossa, and Carthagena, and a few private lines, none of which latter exceed six miles in length. A royal decree, published by the official journal, authorises the installation of a regular telephonic service in Spain. The subscribers will be put in communication with central offices, which will be open to the public for sending verbal messages on payment of a small fee. The laying and working of the lines will be retained by the Government, as well as the ownership of all instruments. There are to be two classes of subscription, one from 8 a.m. to 10 p.m., at £20 per annum, and the other for both day and night at £24. Clubs, casinos, hotels, cafés, theatres, and railway stations will be charged £40, on account of the large number of persons telephoning. Subscribers may forward and receive their telegraphic messages by telephone. They may also send, through the central offices' telephonic messages at the rate of 3d. up to thirty words. Private lines may only be laid between establishments belonging to the same owner; they may not be connected with any telephone or telegraph line; and the *concessionnaires* may only use them for their private communications. The State also reserves the right to suspend them when necessary for the maintenance of public order. All lines now laid in the country will be suppressed as soon as the Government system is laid in their neighbourhood. Lines for connecting the various towns of the kingdom may be laid, provided they communicate directly with a State telephone or telegraph line. The *concessionnaires* will have to lay down these lines at their own cost and risk, and may employ what materials they please, except telephone instruments, which must unite the conditions imposed by the Government, so as to communicate with the State offices. The duty payable to Government will be 23 per cent. of the gross receipts.

The Van Rysselberghe System.—*Apropos* of this ingenious system, the *Bulletin de la Compagnie Internationale des Téléphones*, in an article on Inter-urban Telegraphy, draws attention to the fact that the recent arrangements made for the transmission of music to a distance in Belgium were improvised. For instance, the connections which permitted the King and Queen of the Belgians to hear an opera at Ostend (recorded in *The Electrician* of this week) were not decided upon until after the successful transmission to Antwerp of the Wauxhall Concert at Brussels (described in our last issue). Our contemporary goes on to observe that if theoretically the conception of the inventor is one of ingenious simplicity, its practical application to the Belgian telegraphic system, with its 29,000 kilometres (18,020 miles) of wires, and 855 offices, presents great difficulties in execution. The method adopted for telephoning and telegraphing by the same wires does not depend on the use of microphones or special telephones, though the first experiments were made with their assistance. M. Van Rysselberghe sought, in the first place, by the use of a battery and a special microphone, to amplify the telephonic voice sufficiently to overcome telephonic induction, and he succeeded. But, considering all the difficulties in the way of a complete transformation of the existing plant, he endeavoured to solve the problem by setting himself as a fixed condition the retention of the present telephone instruments. He again succeeded, and in this case by neutralising the induction itself by a graduation of telegraphic currents. Moreover, it appears from experiments made by the telegraph engineers that the Blake microphone, used by the Bell Telephone Company in Belgium, is an excellent instrument, which, indeed, requires regulating; but the company takes the necessary measures for continually keeping the communications in good condition. With these instruments verbal messages have been exchanged between Ostend and Arlon, a distance practically equal to that between Paris and Brussels. It may therefore be affirmed that these instruments serve capitally for exchanging spoken messages between all points of Belgium—as they will be before long; and so much the more that, quite recently, acting on the advice of M. van Rysselberghe, the company has not hesitated to introduce into the batteries which actuate its microphones a modification which will considerably increase their power. The main point, which is now set beyond a doubt, is that by putting in action known and tried methods, telephonic communications, even international, may be established, and that,

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with ordinrry telephones and microphones, verbal messages may be sent along telegraph wires, without diverting them from their original purpose, for such a distance as that comprised between the extreme points of Belgium.

COMETS' TAILS.—Professor R. S. Ball, in his lecture at the Montreal meeting of the British Association, thus accounts for comets' tails:—The next question that arises is as to the physical explanation of the repulsive force which produces these tails. We have to find this force of three different intensities, one about twelve times as great as gravity, one about equal to gravity, and one about a fifth of gravity. Before we postulate the existence of a new force of some unknown character, is is surely our duty to inquire whether there may not be some force already known which is competent to produce the phenomena. The best known repulsive force is of course that with which every one is familiar in connection with electricity. Electricity attracts electricity of an opposite type, while it repels that of the same type. We are also aware that in some mysterious manner the sun is connected with electricity. We know that the phenomena of terrestrial magnetism are connected with soler phenomena, and hence we are tempted to inquire whether the electricity of the sun may not offer an adequate explanation of the phenomenon of the comet's tail. Let us suppose that the sun is attracting a distant body by virtue of gravitation, and at the same time repelling that body in virtue of the fact that the sun and the body are both charged with electricity of the same name. When the attracted body is one of large dimensions, the attraction will vastly exceed the repulsion, and indeed the latter may be entirely neglected in most cases. There is, however, a radical difference between the nature of the electrical forces and the nature of the gravitational forces. The latter are proportional to the masses of the attracting bodies, while the electrical forces are proportional to their surfaces. The mass varies as the cube of the linear measurements, while the surface only varies as the square. The relative efficiency of the electric repulsion in comparison with the gravitational attraction increases as the radius of the particle decreases. It must thus necessarily follow that, no matter how great may be the preponderance of the power of gravitation on masses of finite dimensions, yet it must always be possible, other things being equal, to have a particle so small that the electrical repulsion shall exceed in any required ratio the intensity of the attraction of gravitation. As the comet draws near the sun, the heat it experiences increases, so that the materials of the comet begin to dilate, and to be driven off into a vaporous condition. The matter is thus resolved into a state of extreme subdivision. These separate particles are charged with an electricity similar to that of the sun, and in virtue of their minuteness the intensity of that repulsion has become sufficient to sweep off the particles in a stream, and thus generate the tail. Such is the modern view of the formation of comets' tails.

LIGHTHOUSE EXPERIMENTS.—When Dr. Tyndall resigned his position as scientific adviser to the Board of Trade and the Trinity House, he did so (says the *Journal of Gaslighting*) chiefly on the ground that he could not be a party to what he considered a one-sided investigation as to the respective values of gas, oil, and electricity as lighthouse illuminants. Inasmuch as Sir James N. Douglass, the engineer to the Trinity House, had a pecuniary interest in oil lamps, which he had patented, Professor Tyndall thought he ought not to have any voice—through his Board or otherwise—as an adjudicator in regard to the respective merits of the three illuminants. That Dr. Tyndall was right in urging this point soon became apparent, for the Illuminants Committee would not allow the Commissioners of Irish Lights to exhibit, in the experiments, the most powerful form of gaslight which Mr. Wigham had devised; and believing that the experiments would be quite futile unless this were done, the Irish Commissioners withdrew, and the committee was dissolved. Strange as it may appear, the Board of Trade subsequently entrusted the whole inquiry to the Trinity House; and the experiments frequently referred to of late in our columns have been organised and conducted by them with the assistance of their engineer. So far, they have carried out the programme precisely as the Illuminants Committee intended it to have been carried out. They have erected at the South Foreland three lighthouse lanterns—"A," containing the electric light; "B," the gas light; and "C," the oil light. The towers were placed sufficiently far apart to enable the lights to show to the horizon without blending. The Trinity House, being of the same mind as they were when in the majority of the Illuminants Committee, still, we understand, refused to allow Mr. Wigham's double quadriform gaslight to be shown; alleging, as their reason, that it had not yet been used as the illuminant in any lighthouse. They therefore, in the "B" tower, fixed an ordinary quadriform gaslight, such as is used at Galley Head. In the "A" tower they fixed an electric light of enormous power, produced by the action (combined or separate) of three of De Meritens' largest dynamos. No such electric light has ever been exhibited before at a lighthouse; and in showing this one at the South Foreland, the Trinity House seem to have forgotten the rule under which they excluded Mr. Wigham's best gaslight. In like manner, in "C" tower, they placed three of Douglass's patent oil burners over each other, although no such arrangement had ever been adopted at any lighthouse. The nearest approach is at the new Eddystone Lighthouse, where two such oil burners have been used. Thus, at the very outset of these experiments, gas seems to have been placed unfairly at a disadvantage. Nevertheless, the observations of the lights which have been made (now extending over many months) have shown that, in the ordinary state of the atmosphere, the electric light is the brightest (next comes gas, and last oil); but in hazy weather, and more especially in fog, the order has been: Gas, first; oil, second; electric light, last. If this be so, how much more markedly may we suppose gas will come to the front for lighthouse purposes when Mr. Wigham shows his double quadriform light. The arrangements of the Trinity House for the observation of the lights have been very elaborately and carefully made. Huts have been erected at various distances from the lights, and lines of observation staked out between them and the lanterns. Intimation of the experiments has also been given to mariners navigating the Channel, and they have been requested to observe the lights, and transmit their reports to the Trinity House. The observers in the huts are lightkeepers in the service of the Trinity House, and the masters of the lightships belonging to the Corporation have also been requested to send in reports of their observations. The American and French Governments have appointed representatives to observe and report upon the experiments. It would of course be premature to pass any conclusive judgment respecting the usefulness of these three lights for lighthouse purposes until the various reports have been completed and made public. But enough has transpired to warrant us in the expression of our belief that a great victory has been won by gas; and that if this mode of illumination be given full scope by lighthouse authorities, methods for its application as yet unthought of will speedily be adopted to the great and lasting benefit of seafaring men.

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THE INDUCTION OF CURRENTS IN CORES.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 388.)

Telegraph Cable Analogue.

Let the Telegraph Construction and Maintenance Company be instructed to construct a cable according to the following simple specification, all other details being left to them :—Its electrostatic capacity to vary in simple proportion to the distance from one end O. Its conductivity to vary in simple proportion to the distance from O. That is all, except that its self induction must be negligible. Let r = distance measured from O, then rc and r/k are the capacity and conductivity per unit length, c and k being constants. Let v be the potential at distance r from O, then the current there will be $-\frac{r}{k}\frac{dv}{dr}$, and the charge per unit length will be rcv, making the differential equation of the potential to be

$$r c \dot{v} = -\frac{d}{dr}\left(-\frac{r}{k}\frac{dv}{dr}\right), \quad \text{or} \quad c k \dot{v} = \frac{1}{r}\frac{d}{dr} r \frac{dv}{dr}.$$

This being of the same form as the equation of H in the core, all the previous solutions may be translated into the solutions of problems connected with signalling through the cable.

The strength of force at distance r from the axis of the core corresponds to the potential of the conductor at distance r from the end O; the strength of the circular current in the core to the strength of current in the cable divided by the distance from O. Let the other end of the cable be at P. This corresponds to the boundary of the core.

The cable being constructed, submerged, and a station opened at the end P, let an intelligent operator make connection between the cable and earth through a battery. The electrostatic potential will be propagated through the cable in the same manner as the magnetic force is sent into the core when the coil circuit current is similarly operated upon. There will be no current at the end O, because the conductivity is zero there, so it will be of no use to put a recorder there, though as the potential varies an electrometer might be made use of. But, by cutting a small piece off the end, we may let some current pass, and then use a recorder, without practically altering the nature of the potential propagation.

An artificial line approximately fulfilling the conditions would perhaps serve as well, in case it should not be found convenient to have the cable constructed. Or, it may be left wholly to the imagination.

Example 3. Coil of Any Depth.

When the depth of the coil is not small compared with the radius of the core, an appreciable fraction, or it may be a large fraction, of the magnetic energy is contained between the inner and outer boundary of the coil, *i.e.*, in the wire itself, its covering, and the air spaces, and requires to be taken into consideration, as it modifies somewhat the boundary condition, and the solution. Putting E = 0 in (19), and $H = 4\pi N\Gamma$, we have

$$0 = RH + (L - L_1)\dot{H} + \frac{L_1\rho}{2\pi\mu c}H'$$

for the boundary condition. Put $H = J_0(nr)e^{Dt}$, and it becomes

$$0 = \{R + (L - L_1)D\}J_0(nc) - \frac{L_1\rho n}{2\pi\mu c}J_1(nc).$$

Here, for generality, we let the boundary be at $r = c$, the space from $r = c$ to $r = a$ being air. Putting D in terms of n, we get

$$J_0(nc)/J_1(nc) = (L_1 n\rho/2\pi\mu c)\{R - (L - L_1)n^2\rho/4\pi\mu\}^{-1} \quad . \quad (95)$$

the determinantal equation, whose roots give us the admissible values of n, and therefore also of D.

In finding the coefficients A in the solution $H = \Sigma A J_0(nr)e^{Dt}$, we must remember that now $J_0(nr)$ from $r = 0$ to $r = c$, *i.e.*, from axis to boundary of the core, is not a complete normal system; to complete it, we have $J_0(nc)$ from $r = c$ to $r = a$, and $J_0(nc)\{1 - (r - a)/b\}$ from $r = a$ to $r = a + b$, if b be the depth of the coil. The three taken as a single set constitute a complete normal system to which the conjugate property $\Sigma v_1 v_2 r\mu = 0$ applies. Also remember that the permeability is μ in the core, and unity without it.

Thus,

$$\left.\begin{aligned} 0 = \mu\int_0^c J_0(n_1 r)J_0(n_2 r)rdr + \int_c^a J_0(n_1 c)J_0(n_2 c)rdr \\ + \int_a^{a+b} J_0(n_1 c)J_0(n_2 c)\left(1 - \frac{r-a}{b}\right)^2 rdr \end{aligned}\right\} . \quad (96)$$

is the expression of the conjugate property in its physically most meaningful form, *i.e.*, expressing directly that the mutual energy of two normal systems is *nil*.

Otherwise, use equation (76), putting $J_1(nc)$ in terms of $J_0(nc)$ by (95). We shall obtain, after reductions,

$$\frac{\mu l}{2}\int_0^c J_0(n_1 r)J_0(n_2 r)rdr + (L - L_1)\frac{J_0(n_1 c)}{4\pi N}\frac{J_0(n_2 c)}{4\pi N} = 0 \, . \quad (97)$$

expressing the same truth as (96), but now in terms of the normal systems of current in the coil (instead of magnetic force from $r = c$ to $r = a + b$), and the coefficients of self-induction.

Here $J_0(n_1 c)/4\pi N$ and the similar expression with n_2 instead of n_1 are the proper coil currents corresponding to the normal core magnetic force systems $J_0(n_1 r)$ and $J_0(n_2 r)$. Calling the latter H_1 and H_2, and the former Γ_1 and Γ_2, we may write

$$0 = \frac{\mu l}{4\pi}\int_0^c H_1 H_2 2\pi r dr + (L - L_1)\Gamma_1\Gamma_2 \quad . \quad . \quad (98)$$

expressing, in the simplest form, that the mutual energy of a pair of normal systems is zero, a principle to be considered in a later section. If, then, H_0 and Γ_0 be the complete initial core magnetic force and the coil current, the value of any coefficient A_m in the proper expansion is

$$A_m = \frac{\frac{\mu l}{4\pi}\int H_0 H_m 2\pi r dr + (L - L_1)\Gamma_0\Gamma_m}{\frac{\mu l}{4\pi}\int H_m^2 2\pi r dr + (L - L_1)\Gamma_m^2} \quad . \quad . \quad . \quad (99)$$

The value of the denominator in any case, and of the numerator in case H_0 = constant, is

$$\left.\begin{aligned} \text{Numr.} &= J_1(nc)\left\{\frac{\mu l c}{2n} + \frac{L - L_1}{4\pi N}\frac{\Gamma_0 s n}{1 + (L - L_1)D/R}\right\} \\ \text{Denr.} &= \frac{\mu l c^2}{4}\{J_1(nc)\}^2\left[1 + \frac{\{1 + (L - L_1)/(4\pi N)^2\}s^2 n^2}{\{1 + (L - L_1)D/R\}^2}\right] \end{aligned}\right\} (100)$$

It is useful to use Γ_0 and the coefficients of self-induction, for these reasons. First, not only may H_0 be arbitrary (a function of r), but Γ_0 may have any value we please, quite independent of H_0. Thus we might have it given that $H_0 = 0$; then we use only the second part of the numerator. Γ_0 having any stated value implies a certain distribution of force outside the core, constant between the core and the coil, and varying in the depth of the coil in the manner stated in the earlier part of this section. If there be no force in the core at the same time, there is a discontinuity at its boundary, implying a surface current in the proper direction, and of strength sufficient to cancel the magnetic force in the core due to the coil current. This boundary current is of course purely imaginary, having infinite volume density. But the moment the subsidence commences the discontinuity is rounded off, the surface current spreading into the core, becoming the real induced current accompanying the passage of magnetic force into the core from outside, where it previously existed.

Next, whilst in Example 2 (circuit closed, coil of small depth) we supposed there to be no self-induction in the external circuit, we may now remove this restriction, as well as that relating to the depth of the coil. There may be any amount of self-induction in the external part of the circuit, provided it be unaccompanied by induced currents in metal in the neighbourhood; *e.g.*, there may be other coils in the circuit, either without cores or with cores divided to stop

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induced currents. This self-induction must be included in the value of L above, no other alteration being required, except in equation (96), which does not allow for the external induction.

(TO BE CONTINUED.)

THE BRITISH ASSOCIATION MEETING AT MONTREAL.

On a New Voltmeter.

BY CAPTAIN CARDEW, R.E.

It is quite unnecessary at the present day to dilate on the extreme importance in electric lighting, especially by incandescence, of keeping the pressure or volts on the lamps constant within very small limits. The necessity for this must have forced itself on the notice of all who have had any experience of this lighting. However perfectly the dynamo may be compounded or the engine governed, it is very desirable that the engine driver should have an electric pressure gauge to which he can refer as readily as to his steam gauge. The instruments about to be described were originally designed for the use of engine drivers, and are adapted to the meanest capacity. At the same time they give perfectly trustworthy readings.

There are two ways of measuring the difference of potential or volts between the terminals of a dynamo or any other points in an electric circuit, which we may call the statical and dynamical methods. The former, or measurement of the force of attraction between bodies charged from the two points respectively, is too delicate for the purpose in view, and the latter, or measurement by means of a current produced by connecting these points by a conductor, was therefore adopted. Now, when a current is passing in a conductor it creates a magnetic field in its vicinity by which an effect can be produced on other bodies. The measurement of the current is usually made by observing this effect on another body. This method may fail from two causes:—

1. Other things may affect the body obscuring the effect of the current.
2. Owing to a change in the condition or position of the body, the effect upon it of the current may be altered.

These were obvious objections to entrusting this method to an engine driver in a room full of dynamos and iron machinery, but the current energy produces another effect. It develops heat in the conductor, which causes an expansion of volume to take place in it. This effect of the current energy appeared likely to offer a solution of the difficulty.

The instrument now before you is the outcome of many experiments made with the view of utilising this effect for the exact measurement of the current passing, and thus of the difference of potential existing between the points to which the instrument is applied.

This instrument is extremely simple in principle and construction. It consists essentially of a very fine platinum silver wire, ·0025in. in diameter, enclosed in a brass tube.

The difference of potential to be measured is applied at the ends of the wire, which is heated by the current passing through it. The wire expands on being heated, but is kept stretched by a spring or weight, and the expansion is indicated by suitable apparatus.

The heat produced in any conductor, not containing an electromotive force, by any difference of potential applied to the ends is equal to $\frac{V^2}{R}$ per unit of time, where V is the difference of potential in volts, and R the resistance in ohms. The resulting temperature of the conductor for any difference of potential depends on the temperature and the rate of motion of the particles of the surrounding medium. It will be seen from this that the absolute stretch of the wire, which would accurately measure its rise of temperature, would not be an accurate measure of the current passing through it, or of the volts producing that current. Even when no current was passing the instrument would not maintain an accurate zero, since alterations of atmospheric temperature would affect it.

These defects are obviated by the use of the brass tube enclosing the wire.

The coefficient of expansion of brass for temperature is sensibly the same as that of platinum silver.* Hence, so long as they are both at the same temperature, the zero is unaffected by any alteration of it, or the variations in length of the wire are compensated. When, however, a current is passed through the wire its temperature is raised above that of the surrounding tube, and a perfectly regular current of heat is established between the wire and the tube since all external draughts are prevented. It is therefore the difference of temperature between the wire and the tube that is measured, and this is necessarily constant for the same difference of potential, except for the fact that the resistance of the wire varies slightly with its temperature.

This variation in the resistance has the effect of causing the reading for any volts to be slightly higher on a cold day than it is on a warm one, but as the alloy of platinum and silver used only varies ·035 per cent. per degree centigrade, this error is not worth consideration as long as the surrounding air is at an ordinary temperature.

The considerations guiding the choice of a wire for the purpose were as follow:—

1. It must absorb a minimum of energy, therefore the wire should be as fine as possible and of a high specific resistance.
2. It must follow all variations in the volts with extreme rapidity, and must therefore be formed of a metal of low specific heat, and must offer a large surface for its mass.
3. The material must not be liable to oxidation even at a high temperature.
4. The coefficient of variation of resistance for temperature must be very small.
5. Its elasticity and tensile strength must be high.

A fine platinum silver wire best answered these conditions.

The instruments are practically instantaneous in their indications, and quite dead beat.

Having determined by these considerations the most suitable material and size of wire, the next point to determine was the number of volts that could safely be put on any length of it. With this view one foot of the wire was taken, and the number of volts required to make it just visibly red in a dark room determined to be 21. As the rise of temperature for any number of volts varies as v^2 it is evident that 10 volts would only raise 1ft. to rather less than $\frac{1}{4}$ the amount required to redden it. This rise does not permanently alter the wire.

The working maximum number of volts is therefore taken at 10 per foot. For 200 volts, therefore, 20ft. of the wire is required, but this length need not necessarily be contained in the instrument, although it is advisable to use the same kind and size of wire throughout.

The instruments are generally made to work to 120 volts, and a sufficient length of wire supplied in a metallic box to extend the readings to any required number of volts.

For ordinary purposes it is quite sufficient to extend the limits to which the instrument will measure by putting an incandescent lamp in circuit with it. Thus an instrument for 120 volts has a resistance of about 360 ohms, and if an Edison lamp be added it will easily read to 200 volts.

In order to save the instrument from fusion by excess of current a safety fuse is placed in the circuit. This consists of a short length of finer platinum silver or iridium platinum wire.

As regards the application of the instrument to alternating currents, the presssure which it will indicate with these is the equivalent useful pressure of difference of potential—that is to say, it indicates a difference of potential which, with a continuous current would, if applied to the same wire, do the same amount of work per unit of time. This is evidently what is required to be known for all industrial applications. Of course the absolute difference of potential with an alternating current is continually varying between certain positive and negative limits much higher than the industrial mean, passing in each period of variation through the value 0.

The instrument, however, while indicating the industrial mean follows the variations of pressure sufficiently to emit a musical note corresponding in pitch to the number of alternations per unit of time.

* More perfect compensation is obtained by making two-thirds of the tube of brass, and one-third of iron or tinned iron.

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In the more portable instruments on this principle the extension of the wire is multiplied so as to give a reading over a large dial by delicate wheelwork. This necessarily introduces some complication and chance of error, although the force of the spring is sufficient to easily overcome the friction.

For a standard instrument, not intended to be carried about, it was worth while to eliminate this chance.

In considering this the use of a beam of light as an index naturally suggested itself. As the natural motion in this case was rectilinear, and not angular as in a reflecting galvanometer, it was obvious that the best arrangement was a kind of magic lantern by which a greatly magnified image of a portion of the wire should be projected on a screen.

Two very fine cross wires are fixed on the wire within the field of the lens, which, of course, appear in the magnified image on the screen. The distance between the images of these cross wires constitutes the base line, which is always kept of a certain length, so many feet or inches, by slightly moving the screen or instrument. When the volts are applied the cross hairs move down by the extension of the wires, their images, of course, move up, the upper one soon disappears, but the reading is taken from the lower one, and having once standardised the instrument with a certain base line we can at once obtain the volts corresponding to any movement of the lower image by reference to the curve. The instrument in this form then is one of elementary simplicity, and yet may be called scientific. Here is a rough arrangement to illustrate the principle. It consists of the tube with the wire down the centre terminating in a spring, the lens arranged with the wire and cross hairs in focus, the dark lantern, of course, separate from the tube to avoid error from the heat given off by it and the screen. The instrument has not been standardised, but we will take readings on the portable instrument at the same time.

In order to make a direct reading instrument of this—that is to say, measure off the volts at once—it is sufficient to mark them off from the curve of the instrument on a piece of stiff card or slip of wood of the exact length of the base line.

This form of instrument can be made moderately portable by attaching a camera body to the tube, the image of the wire being received on a ground-glass screen with a scale marked on it. In this case the tube should act as a support to the camera, as the wire can be pulled up as well as down.

The instrument can readily be made to register ordinary variations of electric pressure on mains by simply fixing a very small incandescent lamp—the size used for surgical purposes answers well—on the wire, so that the current through the wire passes also through the lamp and renders it luminous. These lamps are made to take a current of about one-fourth ampere, which gives a good extension to the wire, the maximum current it can safely take being rather under one-third ampere. The image of the filament of the lamp, which in this case is nearly a straight line, is thrown by the lens on a sheet of paper sensitised by the bromide process, all other light being carefully excluded; so long as the volts remain constant the filament will simply produce a magnified image of itself, but any variation of the volts by causing the lamp to slightly shift its position will produce a vertical elongation of the mark.

After each night's work the paper can be developed, fixed, and examined, and the limits of variation of potential for the whole time obtained by simple measurement.

As the companies undertaking house-to-house lighting will be liable to fine if a certain limit of variation is at any time exceeded, registering instruments of this kind will become a necessity.

The only other form of this instrument which is worth mentioning as promising to have a distinct use is a pocket form, with tube not more than a foot long, in which the readings are taken by observing the movement of the wire with a simple microscope. In this case the wire is not pulled by one end, but in the middle, a very slight actual extension being sufficient to produce a perceptible sag in a stretched wire. This idea was suggested to the inventor by Dr. Muirhead.

Mr. Bottomley's Paper on "The Loss of Heat by Radiation and Convection, &c.," will be found on page 441.

ENDLESS SOLENOID GALVANOMETER & VOLTMETER.

BY PROFESSOR JAMES BLYTH, M.A., F.R.S.E.*

The instrument consists of a close spiral of insulated copper wire, about two inches in diameter, bent into the form of an anchor ring, so as to constitute an endless solenoid. The coil is placed in a groove of square section turned on the edge of a ring of brass or wood of suitable thickness and diameter, and is fixed therein by passing a fine cord two or three times through its convolutions, then pulling the ends tight and knotting them firmly together. In this way the convolutions of the spiral are close together on the inside of the groove, but a little wider apart on the outside, leaving V-shaped gaps between them. At both ends of the spiral short lengths of wire are left straight, which, after being well insulated, are twisted together and led to two terminals which serve as electrodes.

The ring containing the endless solenoid is fixed with its plane either vertical or horizontal, as most convenient.

A short magnet is provided, rigidly attached at its centre to the lower end of a fine stiff wire. This magnet is suspended, by means of a silk fibre passed through a fine hole in the upper end of the wire, so as to have its centre in the circular centre-line of the anchor ring formed by the spiral. To the upper end of this wire is attached a long glass fibre or other pointer, which moves over a disc graduated to degrees, or to show amperes directly. When the plane of the containing ring is vertical, the graduated disc is placed horizontally with its plane tangential to the ring; when the ring is horizontal, a graduated sector is attached horizontally to its upper face.

Where weak currents only are to be measured the suspended magnet is allowed to move simply in the field of force due to the earth's magnetism, and we get the following equation for determining the current strength, it being understood that the length of the magnet is very small compared with the other dimensions of the coil:—

Let n = the number of convolutions of the spiral,
r = the radius of the circular centre line,
H = the horizontal intensity of the earth's magnetism,
C = the current strength,
θ = the angle of deflection,

then $$\frac{2nC}{r}\cos\theta = H\sin\theta \qquad C = \frac{Hr}{2n}\tan\theta.$$

From this it will be seen that the galvanometer constant, $\frac{2n}{r}$ admits of easy and accurate determination, seeing that it depends only upon the values of n and r, the one of which is got by simple counting, and the other by careful measurement.

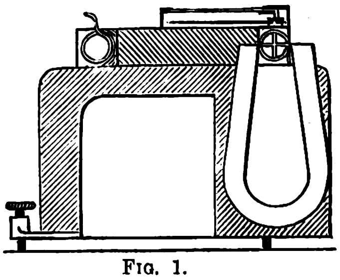

FIG. 1.

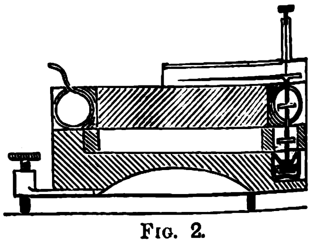

FIG. 2.

When strong currents are to be measured, the suspended magnet is made to move in a field of force of greater intensity than that due to the earth's magnetism. This is obtained by a permanent magnet of suitable form and dimensions placed so that the suspended magnet hangs in the line joining its two poles. When this is done, in order to get the current strength, we must replace H in the above equation by its value increased by the value of the intensity of the field due to the permanent magnet—a quantity which admits of experimental determination. In practice, however, with a controlling magnet, the constant of the instrument will be most easily determined by passing a known current through it and observing the deflection of the needle.

When the plane of the ring is vertical or horizontal, the controlling magnet is simply an ordinary horse-shoe magnet, placed

* A paper read before the Philosophical Society, Glasgow, April, 1884.

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either vertically or horizontally, so as to clasp the ring with its poles opposite the suspended magnet. This form is shown in Fig. 1.

A slightly different form is shown in Fig. 2. In this case two short magnets are rigidly attached to the same axis, so as to form an astatic system. The distance between the magnets is so adjusted that, when the whole is suspended by a silk fibre, the upper magnet has its centre in the centre of the spiral coil, while the lower projects a little below the under surface of the containing ring. The controlling magnet is then fixed so as to have the lower magnet exactly between its poles, and in this way acts solely, or at least mainly, on the lower magnet. A convenient magnet for this purpose consists of a steel bar bent so as to form one convolution of a helix, its ends being kept at the requisite distance apart, as represented in Fig. 3.

This form of magnet admits of its being placed in the proper position relatively to the lower magnetised needle, without, at the same time, projecting at any part from below the containing ring.

This form of galvanometer has one distinct advantage over all others in which permanent controlling magnets are used. In them the current, in the act of being measured, creates a magnetic field of its own, which acts upon the magnetism of the controlling magnets. This action, often repeated, tends to produce greater variations in their magnetism than that due merely to their natural want of magnetic rigidity; and hence, in time, must produce serious alteration in the constants of the instruments. With the endless solenoid, however, no such effect can take place, seeing that, when the current circulates in it, it becomes a closed magnetic shell, and, in consequence, can exert no magnetic force at any point outside itself. Hence, when the constant is once carefully determined, the mere use of the instrument tends to produce no change in it, and any change which takes place must be due either to avoidable accident or to the natural disturbance which takes place in the magnetism of even the best made permanent magnets.

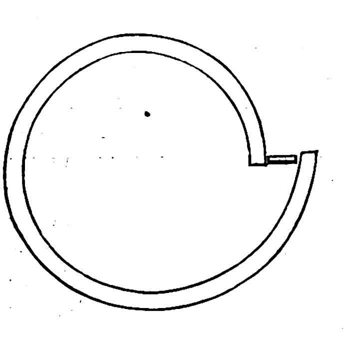

Fig. 3.

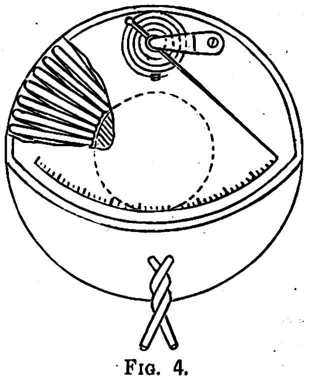

Fig. 4.

To avoid altogether the use of a controlling magnet, I have, in one form of the instrument (Fig. 4), replaced its directive action on the needle by that of a spring, which may either be a flat helical spring, like the hair-spring of a watch, or a cylindrical spiral like the balance-spring of a chronometer. In this form, the axis carrying the magnet, or astatic system, is pivoted between agate cups. The spring is placed a little above the upper surface of the containing ring, and has one end attached to the axis carrying the magnetised needle, while the other is attached rigidly to a suitably placed support. In this way the turning action of the spring on the axis is exactly similar to the action of the hair spring on the balance wheel of a watch. A long pointer is attached to the upper end of the axis, and is set so that the angle between it and the magnet is 45°. In this way the pointer can sweep over a sector having an angle of 90°, which allows it to be made of considerable length and the length of the scale divisions proportionally great. In fact, if $r =$ the radius of the circular centre line of the spiral coil, the length of the pointer is $r\sqrt{2}$ when the angle through which it turns is 90°.

When a current is sent through the solenoid the needle is deflected, until the couple, due to its electro-magnetic action in the needle, is balanced by that acting on the axis due to the flexural rigidity of the spring. The angle of deflection shows the current strength, and, for greater convenience, the scale is graduated so as to indicate amperes directly. With a delicate spring weak currents can be measured in this way. To measure strong currents with the same spring an arrangement is provided, whereby the attachment of the outer end of the spring can be rotated through known angles, as indicated by a separate and shorter pointer. In this way a greater electro-magnetic force is required to produce a given deflection of the needle, and, in consequence, stronger currents can be read. For each position of the short pointer a constant is experimentally determined whereby the indications of the long pointer are made to show the true current. I have also arranged a slight modification of this form, which will sometimes be found more convenient. In it the long pointer is placed parallel to the magnetised needle, and by rotating the outer end of the spiral spring is always brought back to the same position, that position being such that the magnetised needle is perpendicular to the circular centre line of the spiral coil. The position of the second pointer then shows the current strength. When this is done, the position of the magnetised needle is always such that the couple, acting upon it, due to the electro-magnetic action of the current, is greatest.

In the arrangement with a spiral spring, a magnetically astatic system can be dispensed with by simply tilting the plane of the containing ring to such an angle that the axis carrying the magnetised needle is parallel to the line of the dip. When this is done the needle moves in a plane at right angles to the lines of force due to the earth's magnetism, which, in consequence, has no action upon it.

The voltmeters are constructed precisely on the same plan as the galvanometers, the only difference being that the spiral is made of very fine wire, so as to introduce the requisite great resistance.

SELECTED CORRESPONDENCE.

The following correspondence on the subject of electric lighting appeared in *The Times* in continuation of that reprinted in our last issue:—

Sir: Allow me to correct one important statement contained in the letter of "E.G." which appeared in *The Times* of to-day.

He says, "So long as the industry was free and untrammelled it prospered." From this it may be inferred that the promoters of electric lighting previously to the legislation of 1882 possessed facilities at common law which have been taken away from them by that legislation. This is not the case. The first principle of the Bill of 1882, as stated by myself on behalf of the Board of Trade to the Select Committee, was that no existing legal power of supplying electricity should be taken away, and this principle was adopted by the Select Committee and by Parliament.

The legislation of 1882 was rendered necessary by the rush and scramble of electric lighting companies to obtain new parliamentary powers for taking possession of the public streets—powers which, as the experience of gas and water has proved, end in monopoly. The essential feature in the Electric Lighting Act of 1882 is the grant of powers to take possession of the streets, subject to certain conditions. Into the merits of those conditions it is not for me to enter. I merely wish to deny the statement or inference that the companies were by the Act of 1882 deprived of legal powers which they possessed before the passing of that Act.

Your obedient servant,

T. H. Farrer.

Board of Trade, Whitehall Gardens, S.W., Sept. 10.

Sir: The excellent remarks made by you this morning ought to be a sufficient answer to all who are disposed to condemn the Electric Lighting Act, but as it cannot be too often insisted on that this Act has done some good and prevented much harm, perhaps you will allow me to add a few words to what has already been said.

The crowd of professional witnesses who gave evidence before the various Parliamentary Committees to which the Lighting Act and the Provisional Orders Bills were referred, always took a most sanguine view of the situation, and everybody seemed to be more than satisfied when the period of monopoly had been extended from fourteen to twenty-one years; but as soon as the difficult problem of economical production and distribution actually stared electric light companies in the face, nothing was done, and it became necessary to invent excuses for their inaction. Thousands of pounds have been wasted, the public confidence is shaken, and the belief is rapidly gaining ground that "electric lighting does not go ahead" because it is not well enough understood.

The granting of a further extension of the monopoly period might induce many persons to subscribe new capital, but to what useful purpose could it be put by any of the existing companies?

A little firmness on the part of the Board of Trade will effectually put a stop to trading under false pretences—the hope and stay of rotten concerns, and time will prove that our much-abused Electric Lighting Act, with all its faults, has been a blessing to Your obedient servant,

London, September 10. Poor Investor.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

ll letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes ... 425
The Induction of Currents in Cores. By Oliver Heaviside. (Continued.) ... 430
British Association:—
On a New Voltmeter. By Captain Cardew, R.E. ... 431
On Loss of Heat by Radiation and Convection, &c. By J. T. Bottomley ... 441
Endless Solenoid Galvanometer and Voltmeter. By Professor James Blyth. Illustrated ... 432
Selected Correspondence ... 433
Professor Forbes' Report ... 434
The Late J. L. Pulvermacher.. 435
Correspondence ... 435 and 436
Old Cable Stories Retold.—V. (Concluded). By F. C. Webb. 436
The Health Exhibition.—IX. Illustrated ... 438
Professor G. Forbes' Report on the Electric Light at the Health Exhibition ... 442
Direct Spanish Telegraph Company ... 444
Companies' Share List ... 444

PROFESSOR FORBES'S REPORT.

The report, which we reprint elsewhere from the Society of Arts *Journal*, is eminently unsatisfactory—unsatisfactory not from what is said but rather from what is omitted. Indeed the report is little more than an extended catalogue of the exhibits, and contains little or nothing of what is ordinarily understood to constitute a report. We suspect that Professor Forbes is not to blame for this state of things, and that the fault, if fault there be, must be laid at the door of the executive.

The Exhibition has been a success spectatorially and pecuniarily, and success in these days covers a multitude of sins. It is a thrice told tale to relate in terms of the highest commendation the work of the Royal Agricultural Society in connection with farming implements, and especially in connection with those in which steam power is utilised. Reference is made to this work, and there is no intention of dwelling at length upon it merely to strengthen the suggestion that the execution at the Fisheries, the Healtheries, the Inventories, &c., might have taken the same position with regard to electric lighting as the Royal Agricultural Society took in regard to farm implements. Success means a full purse. Why could not the contents of that purse be called upon to supply the necessary funds for substantial prize for the best dynamo, the best arc, and the best incandescent lamp to be awarded after a careful and exhaustive series of tests by the able men at the command of the executive? Suppose that Professor Forbes with say two colleagues and a secretary had been well paid to undertake these tests, we should then have obtained a report that would have been almost invaluable instead of the meagre scarcrow of a report which is now presented to us.

There are not many good openings for real patronage, but surely the electric light presents a field for patronage as yet unfilled. It may be argued that the idea we have mooted is not of the nature of patronage, but with all due deference to those who object, we maintain that it is. When we see firms of the highest reputation inventing, improving, and entering for competition, say, sheaf-binders at the Royal, it becomes unnecessary to do more than point to this fact to show how highly the prize of the Royal Agricultural Society is valued. The obtaining of £100, more or less, is of little import to the Hornsbys, Howards, Woods, or Samuelsons. The value is in the obtaining the prize. The public know that these trials are carried out without fear or favour by men whose reputation and ability cannot be surpassed. Let the executive of the next exhibition bear this in mind, and do for dynamos what the Royal is doing for sheaf-binders—select the jurors not from a clique, not from among those who may have an interest in becoming jurors, but solely with a view to obtain a thoroughly impartial and accurate series of tests.

An objection may be urged against this idea that such tests have been carried out. They have not, and we defy any man to prove that they have. The Munich and the Crystal Palace Exhibitions resulted in reports which are perhaps of more value than any other reports, but these reports are far from exhaustive. Admitting, however, that the argument is valid, admitting that we have had good reports, we reply that we want more good reports. Professor Forbes again and again indicates that progress has been made. What is the exact value of that progress? How about the engine trials of the Royal? Was it understood that one or two were enough? They were tried year after year, and the greatest eagerness was shown by eminent firms to evaporate the maximum quantity of water with the minimum amount of fuel. Year after year improvements were made till the trials were stopped, since when we doubt if similar annual improvement has continued. At any rate, we have not the same faith in stated improvements as when they were proved under the test.

Improvements in dynamos and other electric light accessories may be made and advertised; they are spoken of as great improvements, but their value must necessarily be estimated by interested parties and taken with some reserve. The public want to know the value of these improvements, and there are reasons why the value should be estimated by independent valuers. The inventor may indicate the conditions under which his machine is intended to run, and the machine should be rigidly tested under these conditions, and not under conditions which happen to prevail when the jurors come round. The electric lamp tests, again, should be carried out at the candle-power at which they were intended to run, and not at powers higher or lower. What is the use of telling us that a filament breaks at 600 candles when it is intended to last at six candles? We want to know how long it will last at six candles. We want to know what current it requires for these six candles, and also the E.M.F. required. It is expensive to supply current; it is expensive to give E.M.F. Where is the happy mean; that is, what is the least expensive, E.M.F. and current combined?

The tests we ask for would be expensive, but the only question to be considered is whether the results would warrant

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such expense. We believe the results would be as important and as valuable as the results obtained by the Royal Agricultural Society with portable engines.

It must always be remembered that the public have not the necessary knowledge to enable them to judge of the value of a piece of apparatus, and they would be guided by any such independent authoritative statement as we have suggested. Electric light matters are moving; they would move faster if there was more confidence. The necessary confidence will only come with time and experience, but it would come much sooner and be far more complete were there an annual report detailing the improvements and estimating their value from competent hands.

J. L. PULVERMACHER.

This well-known inventor, whose name will always remain connected with portable voltaic appliances and atmospheric depolarisation, passed away, after a long illness, on the 12th inst. The work done by Mr. Pulvermacher has received in this country very little recognition amongst professional and scientific men, mainly by reason of the extensive system of advertising by means of which the inventor found it necessary to bring his appliances before the public. In justice to him, therefore, it should be pointed out that the portable batteries of Mr. Pulvermacher, however unscientifically they may frequently be applied in the absence of medical supervision, are essentially of a genuine and scientific character, and that they were devised by a man who had made the voltaic battery the study of his life. In this respect they are in strong contrast to the multitude of quasi-voltaic and "magnetic" appliances with which the advertising columns of the daily and weekly press have recently been inundated. It was mainly with a view to obviate the effect of this threatened prominence of sham voltaic curatives, through which the public are swindled on an extensive scale, that such men as Professors Petrina, Kreil, Ettinghausen, and Oppolzer, in Germany, and Golding Bird, Pereira, Ronald Martin, Locock, Holland, and Fergusson, in England, gave their unqualified testimony to the genuine nature and to the "great importance to scientific medicine" of Pulvermacher's voltaic batteries and galvanic appliances.

To Pulvermacher, originally a working jeweller, attending with enthusiastic interest the lectures on natural philosophy of Professor Hessler, at the University of Prague, belongs the merit of having first recognised the fact that in order to transmit a current through a high resistance, more especially when such resistance is that of an electrolyte exhibiting the effect of polarisation of electrodes, a considerable number of very small cells in series is far more efficacious than a single couple of large elements, or even than several such elements, necessarily of an inconvenient and unportable character. To him also is due the credit of recognising the importance of atmospheric depolarisation in the case of single fluid batteries; and his paper, "Sur une pile à un seul liquide se dépolarisant par l'action de l'air atmospherique," read before the Académie des Sciences, by M. du Moncel, in July, 1878, may still be perused with advantage by electrical students. The work done by Pulvermacher, as early as 1846, in relation to magneto-electric machines, may very posssibly be some day disinterred and found to present considerations of importance. But, as we have said, he will be remembered by reason of his work in relation to portable single-fluid voltaic batteries. As a contemporary has well observed, it may to the uninitiated appear a small matter to have invented and perfected a voltaic battery requiring no vessels to contain the "exciting fluid," and no depolarising oxidant save atmospheric air, charged in a few seconds, flexible and portable; but this, with the machinery for its production on a large scale, represents in truth the labour of a lifetime. In this case, it is one that has been better appreciated, from a scientific point of view, in France than in this country

CORRESPONDENCE.

PRACTICAL TELEPHONY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As in your issue of August 30th last you invite a reply to "Wendur," I append a brief answer to his queries.

I consider, if he is fairly acquainted with the subjects named, he is well enough up in theory, and simply requires actual practice in the work so as to become familiar with the construction, working, and adjustment of the apparatus used. The prospects are fairly good for a first-class man, but in the rank and file it is worthless, as the necessary requirements for ordinary inspecting are readily picked up by those who fit up and attend to the instruments, many of whom have had no mechanical training whatever. It is possible, however, with the growth of the business that inspectors will command a better standing than they do at present.—Yours, &c.,

MAGNUS VOLK.

Brighton, 15th Sept., 1884.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Permit me as a practical man to offer "Wendur" a word of advice in reply to his letter to you of the 19th August. "Wendur" is a telephone inspector who wishes to make some progress in his profession, and he asks whether a knowledge of machine construction, mathematics, theoretical mechanics, electricity, telegraphy, and chemistry are "sufficient" to enable him to do so. In a word they are more than sufficient, at least for practical telephony. "Wendur" is undertaking too much. He should remember that a sound practical man is worth any dozen of persons who flaunt the theory alone of some half-dozen branches of electrical science.

Of course attention to business is understood in a "youth" who wants to get on. "Reading the papers" is not at all necessary, although a good joke may be had occasionally in *Punch*, and a real hair-elevator in the *Young Boys' Weekly Budget*.

"Wendur" further inquires—"Is the telephone profession one you would recommend a youth to follow?" It entirely depends upon the youth himself. If he displays any aptitude for the work by all means let him follow it out, the more so if he can bring perseverance, industry, and a sound theoretical basis to his assistance. Telephony is as yet only in its infancy, and there are splendid opportunities in the profession for the proper people.

"Has it good prospects?" asks "Wendur." That depends. If, like me, his tent should be pitched among a number of love-stricken maidens, the prospects are that ere long, instead of being the hairiest of men, he will subscribe himself as I do now,—Yours, &c., BALDHEAD.

AN ELECTRIC LAUNCH.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 23rd of August last there was published a trial with an electric launch, by Mr. Banks, electrician, 32, Corporation-street, Bolton. The launch was 21ft. by 4ft. 16in. beam. The current was supplied by 20 F.S.V. accumulators ($\frac{1}{2}$ horse-power type) actuating a Reckenzaun motor coupled direct to the propeller shaft. The E.M.F. varied from 45 to 35 volts, and the rate of discharge was 31 amperes.

According to the numerous experiments I have made with the F.S.V. accumulators, I have found that the E.M.F. per cell is 2·16 volts just after it has been charged to its full capacity; but soon after the E.M.F. is only two volts, and by discharging run down in a quarter of an hour to 1·96 volt.

The total E.M.F. in Mr. Banks's experiment has thus been $1{\cdot}96 \times 20 = 39{\cdot}2$ volts. The current was 31 amperes (the proper current for $\frac{1}{2}$ horse-power cells is 17-20 amperes), and the energy in electrical horse-power $\frac{39{\cdot}2 \times 31}{746} = 1{\cdot}6$. The motor was constructed to work with 60 volts and about 25

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amperes, and was therefore heated by the excessive current, which must have brought its efficiency down to, say, 54 per cent.

The actual energy given to the propeller has thus been $1{\cdot}6 \times {\cdot}54 = {\cdot}864$ horse-power. The pitch of the propeller was 11in.; and the motor made 450 revolutions per minute. Let us imagine that the propeller had worked without slip; the speed of the boat would then have been $\frac{450 \times 11 \times 60}{12 \times 5280} = 4{\cdot}69$ miles an hour.

The actual speed of the boat must have been about three miles an hour, instead of six miles an hour, as stated.—Yours, &c.,

CH. CAPITO.

THE AVERTISEUR ELECTRO-AUTOMATIQUE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have recently returned from Paris, where I witnessed some most interesting experiments of electricity applied to the most practical purpose of every-day life.

Electricians have achieved much, but in many cases their work is as yet incomplete; it may therefore interest your readers to hear of an invention which has emerged from the embryo state, and being satisfactorily finished, as our French neighbours would say, *ne laisse rien à désirer.*

I allude to the automatic electrical fire alarm, which is mananged by the Société Française Protectrice Contre les Incendies, and which has its offices, 44, Boulevard Haussman, Paris, opposite the Grand Opera.

The method by which their system is worked is as ingenious as it is infallible. A simple wire, which also answers the purpose of the ordinary electric wire, is placed among the drapery of curtains, or along the panelling of a room, and as soon as the fire touches it, the continuous ringing of a bell is heard; at the same time the exact place of its outbreak is marked on an indicator placed in some convenient and prominent position.

The wire encloses in itself the two electric poles. The first is formed by a brass wire surrounded by cotton, and a layer of gutta percha as non-conductor; the second by several brass wires, to which a tin wire is added. The whole is enveloped in cotton and gutta percha, and finally surrounded by cotton or silk the colour of the furniture of the room in which it is placed. This, when artistically arranged, forms quite an additional ornament to the apartment.

At the Ministère des Finances, where this system is established in the most complete manner, an experiment was made some time ago, in the presence of M. de Lesseps, Colonel Conston, and other distinguished authorities, all of whom expressed both satisfaction and astonishment at the result; and I am convinced that the "Avertiseur Electro-Automatique" only requires to be as well known on this side of the Channel to be equally appreciated.

Numerous gold medals attest the success of the "Avertiseur" abroad. Besides being adopted by the Ministère des Finances, it is in full operation at the Mont-de-Piété, Banque de France, at the Exhibition of the Crown Jewels, and all the largest shops in Paris.

I should advise any of your readers in Paris to call at Boulevard Haussman, or 4, Rue Scribe, where the workshops are situated. They will be amply rewarded for their trouble by seeing the numerous purposes to which the "Avertiseur Electro-Automatique" may be applied, and to which it would be impossible to do justice here.—Yours, &c.,

G. F.

NON-MAGNETISABLE WATCHES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On page 406 of your issue of September 13th, headed "A Non-Magnetisable Watch," you state that you would like details of this wonderful watch. I cannot give these, but a simple remedy for *all* watches except those having real compensation balances (which should not be used near powerful magnets) is to have a brass balance and a gold or aluminium bronze *balance* spring fitted instead of the usual steel balance and balance spring. The cost of doing this should not exceed 20s. If watches with compensation balances are used or are already magnetised, they can be served the same way, as the errors due to a magnetised balance far exceed those due to change of temperature. There will then be nothing to prevent a new compensation balance being applied to the watch again when the wearer retires into private life.—Yours, &c.,

Brighton, September 15, 1884. MAGNUS VOLK.

OLD CABLE STORIES RETOLD.—V.

BY F. C. WEBB.

THE CAGLIARI, MALTA, AND CORFU CABLES.

(*Concluded from page* 416.)

On November 14 (1857), at 8 p.m., we started paying out, the "Blazer" towing for a few miles. Shore end was four and a half miles.

On the morning of the 15th it came on to blow, and by about 10 p.m. the ship was rolling very heavily, and the trough in which the cable was led from the fore hold to the brake fetched away, and was replaced by some temporary arrangements after some trouble. The ship was now lightening forward, but the sea came over the after part of the deck, and we were in about two feet of water at the brake, and had to put boards up in front of the door of deck house (which contained the saloon and cabins) and bale the water out of the saloon with buckets. Towards night the wind, which was logged down 6 (or half a gale) on board the "Desperate," moderated. The next day (16th) we sighted the Island of Maritimo, and soon after the "Elba's" engines broke down, and the "Blazer" took her in tow for a short time till we got our engines right. At noon we had payed out 230 miles, and logs showed 198. As regards testing arrangements, Mr. Löffler and another German gentleman, who had been sent from Messrs. Siemens, of Berlin, had brought induction coil Morse instruments for speaking, but for testing only horizontal needle galvanometers unfit for testing work at sea. I therefore rigged up a simple upright galvanometer and reduced battery power till we got a readable deflection. At one time when I was on deck Mr. Löffler pulled my connections down. I reported to Mr. Newall that we were thus paying out without any tests, on which he came down and told Mr. Löffler, in plain and forcible language, that if they interfered again he would throw all their instruments overboard. At one time we were alarmed by an increase of deflection on our galvanometer, and stopped and spoke to Cagliari, and found it had been raining, and thus the land lines had given more earth, so we went on feeling pretty sure this was the cause, and soon after the needle resumed its normal deflection, the sun having come out and dried the insulators. But it was not—speaking in a telegraphic engineering sense—a pleasant situation. We could not disconnect land line to make absolutely sure that cable was perfect, and as we had no picking-up gear we could not pick up, and having no buoys, could not have cut and buoyed. During the night of the 16th, at one time the cable kept slipping out faster than we wished, and Mr. Liddell and I kept putting more weights on, but with very little effect, and soon the cable was going out at nearly nine knots, and at last fouled round one of the horns of the rings in the cable-hold. We stopped, turned astern, and cleared cable, but could not detect what was wrong with the brake till Mr. Newall, coming out of the saloon in his night gear, listened, and his quick mechanical ear missed the slight grating noise of the iron brake strap on the cast-iron drum. On asking then in the engine room where they were pumping the water on to the brake from, we learnt they had turned the donkey-pump on to the bilge, and had thus been pumping greasy water on to the brake, and thus lubricated it. We cleaned brake with waste, and went on all right; but we had had a narrow escape of losing the cable through this thoughtless act

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in the engine room. On the 17th we had a fine morning. At 4 p.m. we had 358 miles out and 308 by logs. Mr. Newall went on ahead in the "Desperate" to arrrange about landing place, the "Blazer" following her. At about 7 p.m. we came up to "Blazer" moored, and showing a green light to indicate position where we were to cut and splice on shore end. We cut, made splice, and payed out to a boat with a red light, moored at entrance to St. George's Bay, Malta. Tried to drag end ashore. Failed. Coiled into boats and payed out and landed end safely by 4 a.m. on the 18th. We had the assistance of two cutters and jolly boat from "Desperate," and a crowd of men. It was pitch dark work in the little rocky bay. When we had landed the end it was led up into a little hut of some sort, and a Morse instrument put in circuit by Mr. Löffler. A crowd of men-of-war's men and natives were trying to peep in and get a look at the novelty. I was quietly smoking a pipe away from the crowd, when two blue jackets, who had just had a peep, passed me, and I overheard one say to the other in a mysterious whisper, "What humbugs me up, Jack, is where the devil all that —— tape comes from?" The paper slip in those days was allowed to froth up all over the place, and had certainly a very Wizard of the North sort of effect. We went back to the "Elba" at 5 a.m., and several of the officers of the "Desperate" joined us over a glass of champagne. We were all very tired and untidy, and Mr. Liddell was sitting in a corner, with his hair rather out of order. There was a flagging of the conversation, when one of the naval officers suddenly exclaimed, "Why, Liddell, you look just like 'Dizzy' out on a spree!" We all looked up, and the likeness to the late Lord Beaconsfield in his younger days was at the moment so striking that there was a general burst of laughter, in which Mr. Liddell heartily joined.

At about nine we went into Malta, landed, and went up to Dunsford's Hotel, and I never shall forget the comfort that night of a clean English hotel, with snow white mosquito curtains to our beds, after our experiences at Cagliari. We were at Malta till the 24th surveying and erecting the land lines from Valletta to St. George's Bay, testing cable, and sending messages. I found a friend in Lieutenant George Campbell, of the 71st, an old schoolfellow of mine. His brother, Sir Donald, also an old friend, was one of the engineers on the construction of the Balaclava Railway during the Crimean War, and just after he died, a few years ago, Dr. Russell, who was at the Cape, noticing his death in the papers, wrote home half a column to the *Daily Telegraph* about Sir Donald, whom he had known in the Crimea, calling him the "genial clever engineer." Donald was always full of fun, and as he spoke French perfectly, and mixed both with the English and French officers in the Crimea, he had many a curious story to tell when he came home. George was a fine, tall fellow, and about the most lively, boisterous fellow in the regiment. He was my guide about Malta, and dined me at the club, and took me to opera, &c. Poor fellow, he, too, has joined the majority.

We had a party of Sappers to help us to put up the land line to St. George's Bay, and having started the work we left on the 24th in the "Elba" for Corfu. We arrived there on the 26th. The "Desperate" took soundings between Malta and Corfu, and came in on the 27th, reporting 1,800 fathoms as the deepest water, and this on that part of line nearest to Mount Etna. We were at Corfu until December 1st, and during this time drove several times across the island to the landing place for the cable, through lovely scenery, with masses of olive, cyprus, and orange trees. We went to a ball at the Governor's (Sir George Young), and saw there the Italian lady who for several years was known as the belle of the Ionian Islands, and has now long since been married to an English officer. That lady's beauty has much to answer for. Several of the "Desperate's" officers were desperately gone. I say nothing about our own party. But, however, belles have nothing to do with cable laying.

Just before we were at Corfu a regiment had been stationed there which had made itself celebrated by a trial in a court of law on a question of practical jokes on one of the officers who was not popular. The questions asked by counsel were nearly always answered by the convenient reply, "I really don't remember." This stuck to the regiment, and when the men-of-war's men at Corfu wanted to irritate a soldier of this regiment, they always said carelessly as they went by, "I say, Bill, I really don't remember."

On December 1st, we landed the end from the "Elba" at 9 a.m., and secured it in a ruined church. We paid out a mile and a half of shore end, and then got a kink just where shore end joined on to the 10 miles of cable we had picked up off Spartivento. We hauled back, cut it out, made a splice and started again by 2 p.m. The 10 miles of picked up cable was troublesome to pay out, and it was 6 p.m. before we got it out, and we then went on at a much faster rate. At noon on the 2nd we had payed out 109 miles and run 86 miles by log. The next morning we sighted Mount Etna. At noon we were about 70 miles from the Mount, which seemed to tower up as if it was only 10 miles off. Every little line and crack in the snow-capped summit was clear and distinct, while the lower part faded off into the haze. By noon we had payed out 253 miles, and logs showed 211. On the 4th we sighted Malta, and at half past noon had payed out 406 miles, when we anchored and spliced on shore end; then slipped anchor and steamed close into bay; anchored and landed end at 7 p.m., having payed out 408 miles. Tried to weigh anchor and carried away chain cable and went into Malta Harbour.

On the 9th Messrs. Newall gave a dinner at Dunsford's to the officers of the "Desperate" and some others, and we sat down a large party. When the breaking up was taking place on the landings of the hotel stairs the youngsters began knocking off all tall hats. I had saved mine once, and placed it in a room. I went in to fetch it, when I found a young midshipman quietly kicking it round the table all to himself, and I rescued it again. At last all had gone down stairs, and as I only heard a faint amount of conversation in the street I concluded it was safe to go out for a stroll, and, lighting a cigar, I went leisurely into the street. But directly I got outside the door there was a cry of "Here's another hat," and in an instant my hat was off and being played football with, for nearly all the party were there. The next morning I received in bed a flat brown paper parcel; it was my hat, sent to me with the compliments of the gun room mess of the "Desperate."

During our stay at Malta I dined once at the ward room mess of H.M.S. "Royal Albert," 131 guns, flag ship. A dinner on board this grand old ship, in full commission as flag ship on a crack station, with her fine ward room, the number of officers and guests, the band playing, and all the paraphernalia of a man-of-war was an imposing sort of entertainment not easily to be forgotten, and is scarcely to be equalled on board our modern ironclads.

We left for Cagliari and Marseilles on the 13th, leaving Mr. Löffler in charge of cables and land-lines.

Altogether the laying of these two cables was a success. The cone and rings and the brake answered perfectly; the dynamometer was the first ever used, and answered fairly well. As regards having no picking-up gear, Mr. Newall informed me that one had been made, but was so heavy he would not have it fixed on board. As regards buoys, I do not know why none had been supplied, for I had nothing to do with the work till I joined the ship at Cagliari. The next trip the "Elba" made we had a fine picking-up machine and bow sheave, which Mr. (now Professor) Fleeming Jenkin designed, with some little advice from me on some points, and we also had a proper set of buoys, ropes, and chains; but this does not belong to the narrative of the laying of the Cagliari, Malta, and Corfu cables.

NEW INSULATOR.—An electric wire insulator has been patented in the United States by Mr. George W. Prince, of Brooklyn, New York. It is formed with a special perforation and slots in its upper, and upwardly inclined grooves in its lower part, whereby the wire can be readily inserted and secured. The wire and insulator are not liable to become disconnected, even if the insulator should be detached from its supporting pin.

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The six engines and eleven boilers may be thus classed and described:—

Engine No. 1 (Fig. 1) is a double engine, that is to say, there are two fixed horizontal engines coupled together. The cylinders are each 19in. in diameter by 32in. stroke. The power, which amounts to about 400 indicated horse-power, is given off by two flywheels, each 12ft. diameter, and weighing collectively 8½ tons. These engines are of an entirely new design, and present many important improvements. They are especially suitable for large electric light installations, also for driving machinery in mills and manufactories of all kinds, pumping machinery, &c. They are made sufficiently strong to work up to 120lb. steam pressure per square inch. The ordinary working pressure is 80lb. Engine No. 2 is of similar design, but the cylinders are 18½in. diameter by 32in. stroke, and the power is given off by one flywheel, 12ft. diameter, and weighing 5¼ tons. Engines No. 1 and No. 2 are both mounted on strong massive cast iron girder frames, and are in all respects constructed to meet the requirements of the electric light. Steam is supplied by six boilers, of the locomotive type, with fire boxes of specially made mild ductile steel. These boilers have been tested by hydraulic pressure to 220lb. per square inch. Engine No. 3 is a compound fixed engine (Fig. 2), with cylinders 15in. and 22½in. diameter respectively by 24in. stroke. Steam for driving this engine is supplied by two high pressure steel boilers. Engine No. 4 (Fig. 3) is a compound semi-fixed engine, with cylinders 12½in. and 20in. diameter respectively by 24in. stroke. Engine No. 5 is a semi-portable engine with two cylinders, each 10½in. diameter by 14in. stroke. Engine No. 6 is a semi-fixed engine, with cylinders each 12in. diameter by 14in. stroke.

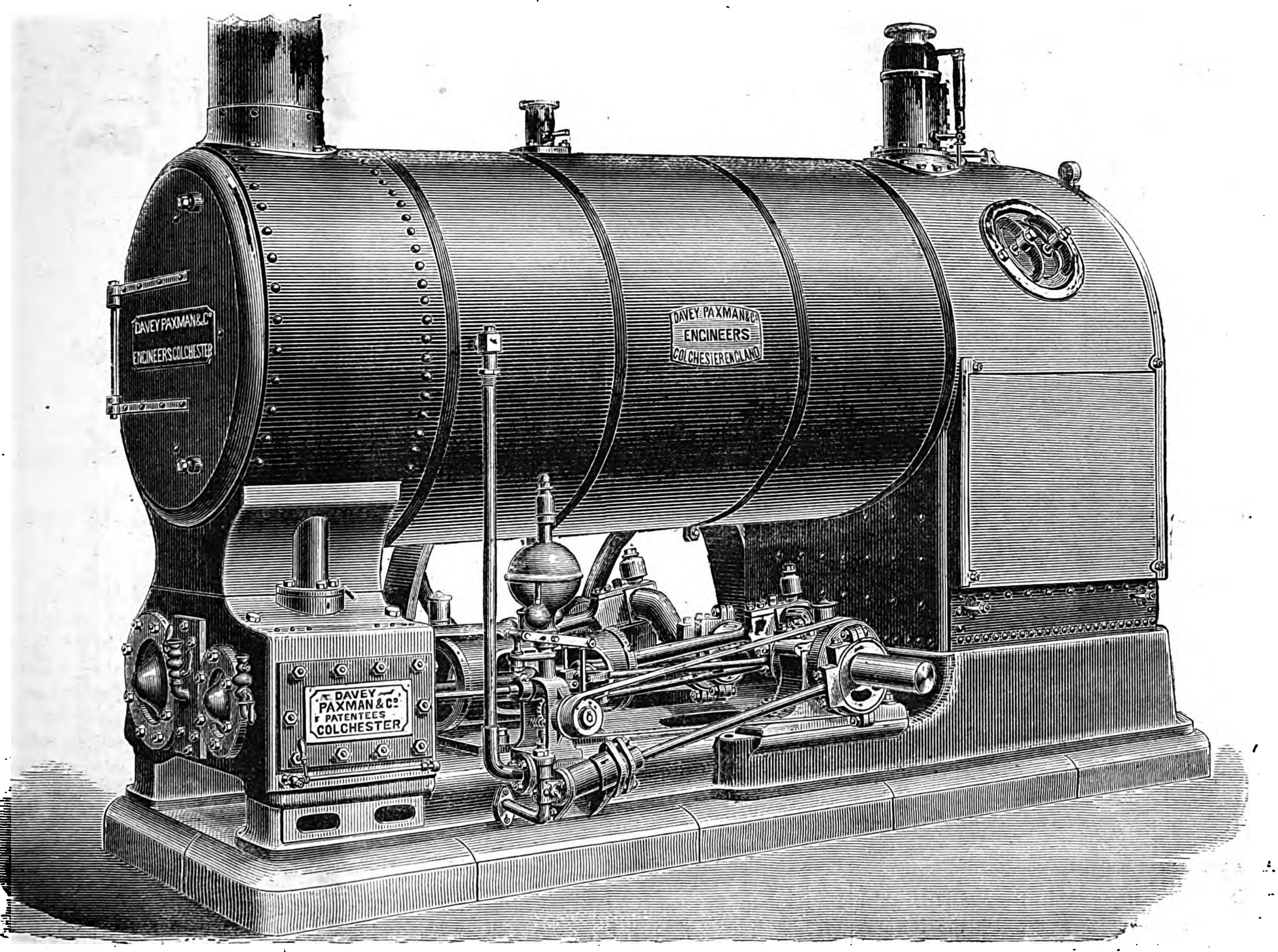

Fig. 3.

Continuing now our description of the exhibits of Messrs. Woodhouse and Rawson we resume, according to promise, with the meter of Mr. J. Cauderay. This instrument is described in a pamphlet issued by the inventor, which, together with the instrument, we have before us while we write. The improvement in dynamos, the possibility of supplying electric energy in large quantities at a moderate cost, and especially the distribution of this energy from house to house in a manner similar to that in which gas is distributed, called for a meter to measure the energy used. A number of such meters have been invented, the best known of which are those of Edison, Sprague, and Hopkinson, yet no one has been found generally acceptable. We cannot say if that of Mr. Cauderay will meet with more favour. It is a very ingenious piece of mechanism, but it has imperfections that will readily be seen without entering into detail. The main points are how the instruments work in practice, their prime cost, and cost of maintenance. Electrical energy meters should be cheap, and as trustworthy at least as gas meters. The one under discussion has this advantage, that it tells the user, by means of dials, the quantity used, and it requires no more education to read than to read an ordinary gas meter.

The instrument we illustrate on page 440 measures coulombs. A second, shown by Messrs. Woodhouse and Rawson, gives lamp hours. The principle is the same, and it will be seen admits of numerous modifications. The coulomb, or ampere per second, is a measure which, from a business point of view, has many advantages. Briefly, the principle is as follows:—An electric clock actuates a cylinder, which is caused to revolve once per hour or per 100 seconds, or other period of time deemed best suited for the purpose in hand. The cylinder is similar to those used for musical boxes, and is furnished with pins or teeth disposed in a special manner around the cylinder. Thus, suppose Fig. A represents the surface of the cylinder opened out, O O represents the zero circle, upon which no tooth is placed. The circles represented by A A A A at equal distances to the

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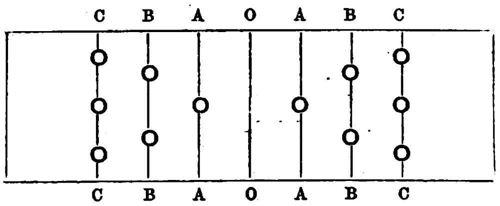
right and left of the zero circle have each one tooth, B B B B have two teeth, C C C C three teeth, and so on. A pointer, *a*,

Fig. A.



carrying at its free end a bronze tooth moves through the arc of a circle, and, according to its position, catches one, two, three or more teeth of the cylinder per revolution, the number depending upon the position of *a*, and this depends upon the strength of current. The revolution of the cylinder pushes back *a*, and, according to the length of the tooth touched, the *vide* Fig. 5. Upon the same spindle as *b* is the pointer *a*, carrying at its free end the bronze tooth. Now if, say, five amperes of current go through the galvanometer D, the needle *b* is deflected to show five amperes current on the scale, while the pointer *a* is deflected opposite that circle on the cylinder which carries five teeth. The pointer comes successively into contact with these five teeth, and being pushed back at each contact, pushes back the lever T, which is connected by a series of levers to the first of a train of wheels, which is thus at each contact moved forward one tooth. The train of wheels is arranged to indicate units, tens, hundreds, and thousands. It will be understood that although we have described the measuring of amperes, any fraction of an ampere can be measured if desired. M. Cauderay claims that a mechanical apparatus is preferable to an electro-chemical, and that his instrument presents many advantages not to be found elsewhere. We confess to a strong admiration for the principle adopted, and hope to find that experience will show this adaptation

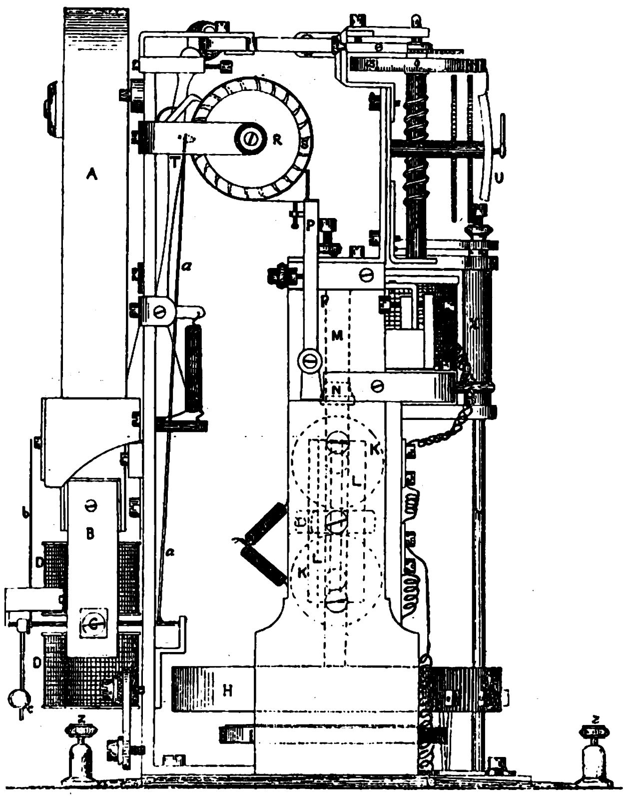


Fig. 4.—Section—Cauderay's Meter.

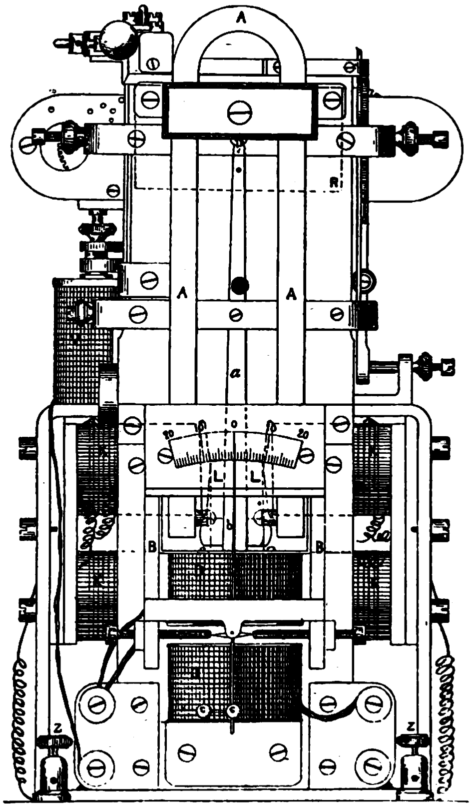


Fig. 5.—Section—Cauderay's Meter.

EXPLANATION OF DIAGRAMS.

Galvanometer.

A a permanent magnet.

a is a spring carrying at its free end a triangular stud of bronze against which the teeth of the cylinder, R, press.

b an indicator pointer.

c balance weights.

B soft iron pole pieces.

C moveable pole pieces, thus allowing the magnetic field to be changed as desired.

D galvanometer coils.

Clock Movement.

H a circular balance-wheel pendulum weighing about 700 grammes,

I regulated by means of the steel spring, I, to make a double oscillation per second, and kept in movement by the

K K L L electro magnets, K K attracting the armatures L L,

M fixed on the axis, M, of the wheel. The electro-magnets have a resistance of about 1,000 ohms, and are placed in a shunt circuit similarly to the plan adopted by M. Hipp

N for his regulators. M also carries the eccentric, N, which transmits motion by means of levers, P, to the cylinder, R. One complete revolution per 100 seconds is made.

O is a contact with a regulator by means of which the current to the electro-magnets is determined.

R is the most prominent feature of the apparatus, consisting of a revolving brass cylinder actuated by H as before described, carrying upon its surface a number of teeth disposed in a manner also described.

S a rachet wheel of 100 teeth, fixed upon the axle of R to alter the reciprocating motion of P into the rotary motion of the cylinder.

T T are transmission levers.

U U V V dials to show the energy passed.

first of a train of wheels is by this means revolved the distance of one or two teeth. Perhaps, however, this will be better seen by reference to Figs. 4 and 5, which have been engraved from drawings in the pamphlet, though slight modifications have been introduced into the instruments before us. Here we have the electro-magnet or galvanometer coils D D, the current through the coils is shown, by the needle *b*, upon a scale, the one before us indicating up to 20 amperes, suitable for the work. The clock portion of the apparatus has received little attention from us, as clocks electrically controlled are well known.

Messrs. Woodhouse and Rawson have other exhibits which deserve attention; indeed this firm is attempting to become a central supply station for electrical sundries, and bids fair to succeed. Staples, saddles, wire, dynamos, lamps, coils, batteries are all to be found in great variety.

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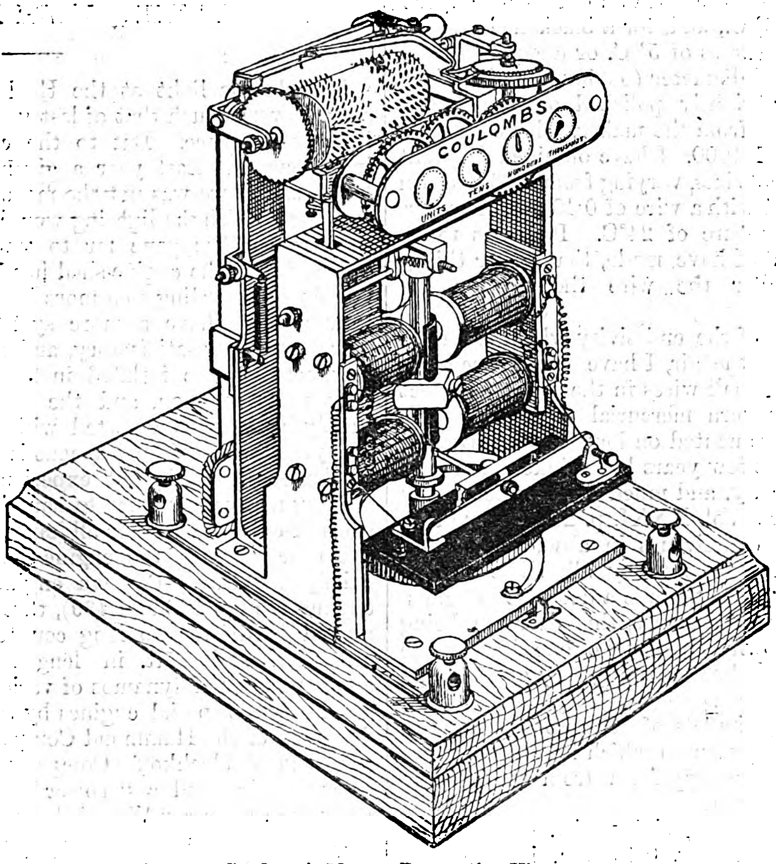
MESSRS. WOODHOUSE AND RAWSON'S EXHIBITS AT THE HEALTH EXHIBITION.



Cauderay's Meter—Perspective View.

THE BRITISH ASSOCIATION MEETING AT MONTREAL.

On Loss of Heat by Radiation and Convection, &c.*

BY J. T. BOTTOMLEY, M.A., F.R.S.E.

In the course of a series of experiments on the heating of conductors by the electric current, which were carried on during the past winter, I obtained a considerable number of results which both gave me the means of calculating the *emissivity* for heat in absolute measure of various surfaces under different circumstances, and also caused me to undertake a number of special experiments on the subject. These experiments are still in progress, and I am making preparation for a more extended and complete series; but a brief notice of some of the results already arrived at may not be without interest to the British Association.

The experiments were made on wires of various sizes, some of them covered and some of them bare, cooling in air at ordinary temperatures, and at normal and also at very much reduced pressures. The mode of experimenting was as follows:—

A current passing through a wire generates heat, the amount of which is given by Joule's well-known law

$$H = C^2 R/J \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where C is the current, R the electrical resistance, J Joule's equivalent, and H the quantity of heat generated per unit of time, each being reckoned in C.G.S. units. Let l be the length of the wire, d its diameter, and σ_t the specific resistance of the material at temperature $t°$ (at which temperature let us suppose that the wire in the given external conditions is maintained by the current). Then

$$R = \frac{\sigma_t l}{\frac{1}{4}\pi d^2} = \frac{4\sigma_t l}{\pi d^2}$$

Hence from (1)

$$H = \frac{C^2}{J} \cdot \frac{4\sigma_t l}{\pi d^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Consider, now, that the wire suspended in the air is losing heat by its surface, and let us suppose that it neither loses nor gains heat by its ends. Let H′ be the quantity lost by emission from the surface per unit of time. Let e be the emissivity or quantity of heat lost per unit time per unit area of the cooling surface per unit difference of temperatures between the cooling surface and the surrounding; and $t°$ being, as has been said above, the temperature of the wire, let θ be the temperature of the surroundings. Then

$$H' = \pi d l \, . \, e (t - \theta) \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

But when the wire has acquired a permanent temperature, with the current flowing through it, there is as much heat being lost at the sides as is being generated by the current. In this case H = H′; and we obtain the expression for e

$$e = \frac{4 C^2 \sigma_t}{J \pi^2 d^3 (t - \theta)} \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

My experiments consist in measuring the strength of the current and the temperature of the wire, the latter being effected by measuring the electric resistance of a known length of the wire while the current is flowing through it, and hence inferring the temperature. These being known, and likewise the temperature of the surroundings, we have all the data for finding e, the emissivity of the surface in absolute measure. The experiments of Mr. D. Macfarlane giving emissivities in absolute measure are well known, and are of undoubted accuracy. They were communicated to the Royal Society (*Proc. Roy. Soc.*, 1872, p. 93); and the results are quoted in Professor Everett's "Units and Physical Constants" (chap. ix. sec. 137). These experiments were made with a copper globe about 4cm. in diameter, suspended in a cylindrical chamber, with top and bottom, about 60cm. in diameter, and 60cm. high. The results may be briefly summed up as follows:—

Mr. Macfarlane finds an emissivity of about 1/4000th of the thermal unit C.G.S. per square centimetre per second per

* Paper "On Loss of Heat by Radiation and Convection, as affected by the Dimensions of the Cooling Body; and on Cooling in Vacuum," read before Section A (Mathematical and Physical Science), British Association, Montreal, 1884.

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degree of difference of temperatures between cooling body and surroundings for a polished surface, with an excess of temperature of a little more than 60° C., and, for a blackened surface, the same emissivity with an excess of 5° C. or under.

Using round wires of small diameter (0·85mm. and under), and with the surfaces either brightly polished or in common dull condition of a wire fresh from the maker, I have found a much larger emissivity than 1/4000. I have obtained different values of *e* for wires of different sizes, varying from 1/2000 down to 1/400, which was obtained with a wire of 0·40mm. diameter, and with an excess of temperature of 24°C. It seems to be shown by all the experiments I have made, that, other things being the same, the smaller the wire the greater the emissivity.

To do away with the part of the emissivity which is due to convection and conduction by the air, I have commenced experiments on loss of heat by small wires in the nearly perfect vacuum afforded by the modern mercurial air-pump. This part of the subject was experimented on long ago by Dulong and Petit, and within the last few years by Winkelmann and by Kundt and Warburg; lastly, and much more perfectly, by Mr. Crookes (*Proc.* Roy. Soc., Vol. XXXI. p. 239), though in no case, I believe, were the emissivities in absolute measure determined. The conclusion come to by all these experimenters is the same, namely, that there is a decrease of emissivity due to lowering of the air-pressure, this decrease being very small for a reduction down to one-half or one-third of the ordinary atmospheric pressure, but becoming very great as the vacuum approaches completeness.

The very interesting experiments of Mr. Crookes seem to show that, even with the high vacuum which he obtained, the effect of the residual gas in carrying off heat from the cooling body was far from being annulled.

The following table shows the emissivity of a copper wire with bright surface half a metre long, 0·40 mm. in diameter, and sealed into a glass tube about 1·5 cm. in internal diameter:—

Current amperes.	Pressure, 760 millims.		Pressure, 380 millims.		Pressure, 180 millims.		Very high vacuum pump worked continuously.	
	$t-\theta$	e	$t-\theta$	e	$t-\theta$	e	$t-\theta$	e
	°		°		°		°	
1	4·7	1/1822	4·5	1/1784	5·5	1/2176	17	1/6443
2	22·5	1/2084	21·5	1/1996	23·5	1/2174	68	1/5620
3	56	1/2114	58	1/2180	55	1/2082	140 ?	1/4606*

* Temperature probably much too low. The wire, sagging down, touched the inside of the glass tube in several points.

The following table may also be found interesting. It shows the emissivity in absolute measure of some materials commonly used as insulating coverings for wires:—

Specifying number B.W.G. and nature of covering.	Length of wire. Centims.	Resist. of 100 centims. B.A. units.	Dia. of wire in millims.	Dia. of covered wire, outside.	Current (amp).	$t-\theta$	Emissivity.
No. 22, silk covered...	100	·0395	·76	·96	10	23°·4	0·001333
No. 26, cotton covered	100	·094	·50	·88	10	58	0·001385
No. 26, silk covered...	100	·1115	·45	·57	9·8	70	0·002020
No. 22, gutta percha..	100	·0455	·72	1·67	10	24	0·000854
No. 22, tinned, gutta percha covered, and double cotton covered outside ...	100	·0432	·73	1·86	10	25	0·000759

The estimated traffic receipts of the West India and Panama Telegraph Company for the half month ended the 5th September are £2,096, as compared with £2,404 in the corresponding period of 1883.

The traffic receipts of the Western and Brazilian Telegraph Company for the week ended 11th September were £2,630, after deducting the "fifth" of the gross receipts payable to the London Pratino-Brazilian Telegraph Company.

PROF. G. FORBES' REPORT ON THE ELECTRIC LIGHT AT THE HEALTH EXHIBITION.*

The electric light at the Health Exhibition this year resembles very much that of last year at the Fisheries Exhibition in the same place. But to the critical eye there is a vast improvement. Last year a gigantic system was installed in haste, and there was not the means to estimate properly the extent to which the lighting would be carried. The experience then gained has gone far to smooth away the preliminary difficulties. The engine-shed has been enlarged, and the plant laid down according to a more intelligible scheme, and all the arrangements have a more systematic basis. The result is correspondingly satisfactory, and serves as the best connecting link between the isolated installations which have hitherto been most common, and the centralised stations for large supply which it is expected will soon be generally demanded. The most evident improvement is in the general arrangement of the engine-shed; but experience has also done much in guiding many companies to sounder views as to the dimensions of cables and other all-important details.

To begin with the engine-shed, steam-power is supplied chiefly by Davey-Paxman engines (for illustrations of these engines see pp. 438 and 439), three of these engines being employed to drive two long countershafts in one line; these are 60ft. and 45ft. in length respectively. From these a vast number of dynamos of various kinds are driven. There are also three special engines by the same makers working the dynamos of the Hammond Company, the Gülcher Company, and the Jablochkoff Company respectively. A Hodgson rotary engine and a "Tower" spherical engine are also at work each upon a "Victoria" dynamo of the Brush Company. A gas-engine is also shown close by, driving another "Victoria" dynamo, to illustrate Mr. Dowson's system of generating gas for the purposes of motive power.

One of Lautensach and Bittner's gigantic thermopiles has also been placed in the engine-shed, but it does not seem to have been put in operation up to the present date.

Nearly the whole length of the building is occupied on one side by two large Davey-Paxman pairs of horizontal engines, and the six boilers required for this duty. These boilers also supply steam to the two rotary engines mentioned above.

These six boilers are all connected together. One main water pipe runs along the whole length of the six, and the pumps are so connected that if one fails the others act and supply through the main. The pumps are by Mumford, of Colchester. There is a throttle-valve attached for the feed of each boiler. Each boiler has an independent safety valve and stop valve. The exhaust steam is carried away by the funnels of these boilers. The steam pipes to the two engines are connected with all the boilers.

Each of the two large engines indicate about 350 horse-power. The one which drives the 60ft. countershaft has a 19in. cylinder and 32in. stroke. It is mounted on girders instead of being upon a solid bed-plate. This is for convenience of export. The cylinders are connected to the girders by strong brackets, which give great rigidity. The main valve is in a separate case to the cut-off valve, and this involves the use of less pressure to move the main valve. The cut-off can be varied from 0 up to ¾. There is a cylinder on each side of the driving wheel, and one governor acts upon both. The governor is supplied with a spring, to vary the action of gravity, so that the speed may be increased. It is not driven by belts, but by toothed-wheel gearing. The efficiency of one of these governors was shown on a recent occasion here, when the 21in. link leather belt broke when in full action, and the speed changed by barely a revolution a minute. Schönheyder's lubricator is used in this engine. There are two driving pulleys 12ft. diameter and 16in. wide. The engine runs at 72 revolutions, and the pressure of steam has been 85lb. These driving wheels have each a 15in. belt of linked leather driving a pair of 39in. pulleys on the long countershaft, the distance between centres being 31ft.

* The official report as published in the *Society of Arts Journal*.

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The second large double cylinder engine drives a countershaft of 45ft. length. This engine resembles the first, but it has an 18½in. cylinder, with a 32in. stroke. It has only one driving pulley, 12ft. diameter and 24in. wide. The 19in. linked leather belt which broke on this work has been replaced by another, 24in. wide.

The third engine, of Messrs. Davey and Paxman, is a fixed horizontal compound engine, in use by the Hammond Company to drive the Ferranti 1,000-lighter alternate current machine, a 40-lighter Brush machine, and a Ferranti 200 incandescent lighter. It has a single gridiron valve and a cut-off valve. The exhaust valve is in the same case as the slide valve of the low-pressure cylinder; the latter cuts off at half stroke. The high-pressure cylinder has a diameter of piston of 15in. and a stroke of 2ft., and the low pressure 22in. with a 2ft. stroke. This engine has indicated up to 220 horse-power, with a pressure of 120lb. It drives two pulleys, one 10ft. diameter and 16in. wide for the large Ferranti machine; the other a smaller one for the other two dynamos. This engine is fed by two boilers called a 50 and a 16 horse-power boiler respectively. These have each a donkey pump and injector.

The fourth engine is a compound one used for seven Fülcher dynamos. It resembles the last, but the diameters of the high and low pressure cylinders are 12¼ and 20½in., and the stroke 2ft. It runs at 100 revolutions. With its attached boiler it can indicate 130 horse-power. The driving wheel is 8ft. 6in. by 16in.

Another semi-fixed compound engine on the top of its boiler works the Jablochkoff dynamos. It has no special features of interest.

The first large engine described is assisted in driving the principal countershaft by a 25 horse-power engine, working, it is said, up to 100 horse-power. Altogether over 1,100 horse-power is developed in the engine shed.

The main countershaft, 60ft. long, drives two secondary countershafts, one of them driving six Gramme machines of the British Electric Light Company—viz., two A's, one D, and three E's; the other driving 10 double Edison machines. It also drives the following dynamos direct:—One Bürgin, four Pilsen-Joel, one Siemens alternate current with exciter (small), and two Paterson and Cooper "Phœnix" machines, all these on one side of the countershaft, and on the other side one huge Siemens direct machine for 420 amperes and 80 volts, a Clerk machine with Siemens exciter (for the "Sun" lamps), two large low resistance Siemens alternate current machines with exciter, and another Siemens direct current dynamo. An Elphinstone and Vincent 400 lighter machine is also in place and at work.

The second countershaft, 45 feet long, drives three Hochhausen dynamos, one Brush (23 arcs), one Opperman with exciter, and one Gerard.

A great deal of interest attaches to the large machine exhibited by the Hammond Company. This is a 1,000 incandescent lamp alternate current machine by Ferranti. It resembles his well-known type of machine in many respects, but is conspicuous for the perfecting of details of construction, and for some novelties which are introduced. It is fed by a large quantity of Siemens direct current dynamos, attached to the same shaft as the alternate current machine. The shaft has a large bearing on each side of the Ferranti armature, of the fly-wheel, and of the Siemens armature, and has in addition a thrust bearing. These bearings are lubricated under pressure, the oil being collected in a reservoir, filtered, and pumped up to a supply reservoir. In the other types of Ferranti machine it has been found that, to prevent abrasion, the collecting rings must be oiled, and the resistance thus introduced is in many cases equal to the total resistance of the armature. In the present type of machine the terminal wires are attached to rings on the shaft which rotate within hollow rings, the intermediate space being filled with mercury to complete the electrical contact. This arrangement seems to work admirably. This device was patented by me in 1883. It has been said that the direct and alternate machines are on the same shaft. This is not strictly so, for the shaft of the Siemens machine is driven from that of the Ferranti machine through a leather ring clamped to each of the shafts. The Siemens machine gives 30 amperes and 120 volts, and works through the two sets of 24 Ferranti field magnets, each set of 24 being connected in parallel. The Ferranti machine gives 400 volts at 600 revolutions. It supplies Woodhouse and Rawson lamps in the Aquarium refreshment bar and the dining room in the conservatory.

Another large machine deserving special attention is the Siemens machine, exhibited by the water companies. It is called a B 2 dynamo. It is designed to give 420 amperes current, with 80 volts electromotive force, and is used for the fountain illuminations. On the armatures there are ribs of copper from end to end, held bound by strong metal bands enclosing them. These bands have their greatest width radial, to prevent local currents being developed, and are in pairs, and two pairs go to each terminal commutator. There are about 20 arms to the commutator. There are two pairs of brushes, each pair being side by side. The width of each brush is 4in. The position of the brushes is adjusted by a worm wheel. The machine is compound wound, the series winding goes through the four arms of the field magnets in parallel, and is of wire about ¼in. diameter; the shunt winding goes round all four arms in succession, and is of No. 12 wire. The mechanical and constructive details of this machine are worthy of close inspection.

TABLE A.

System.	No. of Sect.	B.W.G. No.	Amps.	Volts.
Siemens { main	1	19/16	160	76
Siemens { return	4	7/16	40	304
„ Swan	3	19/16	142	200
Bowman	1	14/16	9	350
Lea	1	14/16	22	260
Gramme-Brockie	1	14/16	12	400
Brush (part)	1	14/16	} 11	1,200
„ (part)	1	7/16		
Brush-Hammond (part)	—	14/16	} 11	2,000
„ „ (part)	—	7/16		
Pilsen-Joel	3	7/18	9	600
Gülcher	2	9/12	200	65
Hochhausen	1	7/18	12	1,645
Clerk's Sun Lamp (part)	1	7/20	} 9	500
„ „ (part)	1	7/16		
Hochhausen (mast)	1	14/16	20	250
Edison Swan	1	3/4	630	110
Oppermann	1	19/14	53	200
Victoria (driven by Tower engine)	1	19/16	70	160
Sweden-Gatehouse	3	19/16	220	88
Ferranti	1	19/12	180	250
„	1	14/16	20	250

A machine shown by the Brush Company shows the enormous improvement which can be introduced by recognising, and so dispensing with, the local currents in the mass of iron constituting the armature. In this machine the armature is built upon a coil of hoop iron, with H pieces let in during the winding to support the coils. A very great gain is said to have been obtained by this alteration.

The Hopkinson-Edison type of machine, manufactured by the Edison Company at New York, is exhibited by the Edison-Swan Company.

Of other machines mention may be made of the cheap classes of direct current and alternate current machines shown by Oppermann. The Gerard Company also show some small and cheap machines; among these is a very small compact laboratory machine, suitable to work with a treadle, which works four incandescent lamps.

The Victoria dynamos are on the model of the Shuckert machines, which, as turned out at Nürnberg, have acquired so high a reputation. In the Victoria, however, there are four

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poles, and the resulting pairs of coils on the armature are in parallel, so that there are only two brushes.

The Gramme, Hochhausen, Gülcher, Jablochkoff, Bürgin, Phœnix, and other machines require no special notice here.

In the Consolidated Company's exhibit their secondary batteries are charged by a compact Parker-Elwell machine, with an 8in. armature, giving 25 to 30 amperes and 130 volts; when run for a short time it can give 60 amperes without injury.

Having thus passed in review the dynamos at the Exhibition, it becomes a matter of interest to learn the size of cables used by different firms, and the current carried by them. In the accompanying table (A) the name of the firm, or other distinguishing mark, is given in the first column. The number of cables in parallel, or sections, is given in the second. Size of wire is in the third, thus 7/16 means 7 wires of No. 16 in a cable. The current in amperes fills the fourth, and the fifth gives the amperes in volts.

The total illumination is over 5,000 incandescent lamps, besides some 300 arc lamps. It is worthy of remark that Sir F. Bolton's fountain display uses up from 120 to 180 horsepower in the illuminations. As this exhibition is to a great extent illustrative of what can be done on a large scale, the nature of the lighting is worthy of record. The following facts have accordingly been compiled for the purpose:—

Arc Lighting.—The small corridor and the south promenade and vegetarian room are lighted by 11 Ball lamps with 1 Ball dynamo; the electric machinery room by 6 Werner and 6 Cardew lamps, fed by 1 Brush machine; the west corridor and the south annexe by 8 Clark Bowman lamps with 1 Phœnix dynamo; Old London by 5 Lea lamps with 1 Gramme dynamo; the south central avenue and part of the east and west central gallery are lighted by 60 Jablochkoff candles with 3 machines, and there is a fourth spare one; in the west central gallery, 7 Brockie lamps and 1 Gramme dynamo; west and east annexes, 23 Brush lamps and 1 dynamo; east corridor, west and east quadrants, east arcade, and Du-Val dining room, 40 lamps and 1 Brush dynamo by the Hammond Company; west gallery, 39 Pilsen lamps, 3 Schuckert dynamos; central gallery, 29 lamps, and 1 machine by Hochhausen; central fountain by 1 lamp and machine by Crompton, 10 lamps and 1 machine by Clerk, the latter being also distributed in the cascades and water pavilion garden. The Clerk machine is designed for 3 circuits of 10 lamps each. The Queen's-gate entrance has a Fox lamp and Oppermann machine; the masthead has 6 lamps on 1 machine by Hochhausen, and the conservatory has 4 lamps on 1 machine by Siemens.

Incandescent Lighting.—Ten Edison machines light the following spaces:—Entrance vestibule, 23 Swan lamps and 107 Edison lamps; the arts gallery, 172 Swan and 122 Edison; Bertram and Roberts' dining rooms, 64 Swan and 264 Edison; cheap dining room, 31 Swan and 115 Edison; literary superintendent's room, 20 Edison. The south gallery, 2 Siemens alternate machines with 2 exciters—1,063 Swan lamps; dairies, 2 Gülcher machines, 370 Crookes lamps; Old London, 1 Gramme and exciter, and 30 lamps by Mackie; east central gallery, 340 Gatehouse lamps and 1 Elphinstone-Vincent dynamo; water company pavilion, 1 Oppermann alternate current machine with exciter, and 234 Woodhouse and Rawson lamps; Prince of Wales Pavilion, 1 Siemens with excitor, 180 Swan lamps, and 1 Siemens with exciter to 40 Woodhouse and Rawson 25 volt and 10 candle-power, besides ten of 50 volts and 20 candle-power; the aquarium, west arcade, and west dining rooms and tea rooms, 1 Ferranti alternate current dynamo with Siemens exciter, and 909 Woodhouse and Rawson lamps; refreshment bar, 1 Phœnix dynamo and 40 half Bernstein lamps of 25 candle-power; cocoa tavern, 1 Victoria dynamo, and 100 Victoria lamps of 100 volts and 20 candles; Chinese restaurant, 204 Crookes 50 volt lamps, which with 300 more are fed by 6 Gülcher machines; Indian Court, 38 Bernstein lamps on a Hochhausen machine. Nineteen of these are series on two parallels. Doulton's pavilion has 24 Gerard lamps of 50 candles on 2 Gerard machines.

The only secondary batteries in regular action are those of the Consolidated Company in the machinery in motion gallery. The plates are made of corrugated strips of lead coiled into a disc and pressed into a square form.

Twice the lighting has failed up to this date (August 14). Once a driving belt gave way, and once a boiler-feeding valve stuck, and the boilers being all connected together the steam escaped. (It may be said that the boilers being connected in parallel, and one of them short circuiting the mains, the whole of them were burnt up or run dry.)

Mr. W. D. Gooch has superintended all the arrangements. Everything seems to be as well arranged as is possible with so great a mixture of systems in use. This is the most extensive application of electric lighting hitherto seen in this country.

Direct Spanish Telegraph Company.

Report of the directors for the half year ended 30th June, 1884, to be presented at the general meeting of shareholders, to be held on Monday, 29th inst. The accounts for the half year ended 30th June, 1884, show a balance to the credit of profit and loss of £3,844 5s. The traffic receipts are £334 18s. 8d. in excess of those for the corresponding half year of 1883, and show an increase of £243 11s. 5d. over those for last half year. The original Bilbao cable which, as mentioned in the last report, broke down on the 10th of February, was restored on the 9th of April. The Marseilles-Barcelona cable remained in perfect working order throughout the half year, and continues so. The duplicate cable between Bilbao and England was successfully completed on the 12th of May, and was opened to traffic on the 13th of June, since when it has worked perfectly. The original Bilbao cable broke down again on the 17th of July last, but as the new cable is sufficient for the requirements of the service, the directors do not contemplate restoring the original cable at present. The cost of the repairs of the original Bilbao cable in April last amounted to £4,292 19s. 10d. Of this amount, £3,092 19s. 10d. have been paid out of revenue, and £1,200 have been taken from the reserve fund, which is thereby reduced to £884 1s. 10d. After providing for the payment of the debenture interest (£590), of the dividend on the Preference shares (£3,000), and of £200 towards the reduction of the preliminary expenses account, there will remain a balance of £54 5s., which it is proposed to carry to next account. The dividend warrants on the preference shares will be issued when the remittances from Spain for the balance of telegraph accounts to 30th June last are received, and these are expected in the course of next month.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Sept. 17.		Business Done Week Ending Sept. 17. Highest.	Lowest.
Anglo-American	31,	32	31	30¾
Do. Preferred	55,	56	55¾	54½
Do. Deferred	6¾,	7¼	7	6⅝
Brazilian Submarine	11⅛,	11⅝	11⅝	11¼
Cuba	10¾,	11¼	—	—
Do. Preference	17,	18	—	—
Direct Spanish	4,	4½	—	—
Do. Preference	14¼,	15¼	15	14¾
Direct United States Cable	10⅜,	10⅝	10⅜	9 13-16
Eastern Telegraph	11⅛,	11⅜	11⅜	11¼
Do. 6 per Cent. Preference	13¼,	13¾	13⅝	13¼
Do. 5 per Cent. Debentures, 1899	104,	107	105¾	—
Eastern Extension	11⅞,	12⅜	11 15-16	11⅝
German Union	9¾,	10¼	9¾	—
Globe Telegraph and Trust	6⅞,	7⅛	7 1-16	6⅝
Do. Preference	12⅝,	12⅞	12¾	12 9-16
Great Northern	13⅜,	13⅞	13⅞	—
Indo-European	31,	32	32	—
Reuter's	8,	8½	—	—
Submarine	165,	175	—	—
West India and Panama	⅞,	1⅛	⅞	—
Do. 1st Preference	7¼,	7¾	7½	—
Western Brazilian	7⅛,	7⅝	7 3-16	6⅞
Western Union 7 per Cent. 1st Mortgage	123,	125	—	—
Do. 6 per Cent. Sterling Bonds	100,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	¼,	⅜	—	—
Oriental	⅛,	⅜	—	—
United Telephone	12,	12½	12 7-16	12

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1¼,	1½	1 9-16	1 7-16
Do. (fully paid)	2¼,	2¾	2¾	2½
Hammond Light (£3 15s. paid)	⅛,	⅜	⅜	¼
Swan	—	—	—	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	32½,	33½	33½	32¾
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23½	—

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NOTES.

American Telegrams.—The average number of words in American telegrams is 14 by day, but rather higher during the night, when messages are sent at reduced prices.

Personal.—Mr. C. H. Baker, formerly assistant-superintendent Eastern Telegraph Company, Suez, has been appointed to the managership of the Central and South American Company's station at Panama.

Electricity and Adulteration.—The electrolysis of red wine, with a microscopic examination of the deposit formed, is, according to L. Monrad Krohn, a certain means of detecting extraneous colouring matter.

Society of Telegraph Engineers and Electricians.—The list of members, corrected to the end of June last, shows that a total of 1,256 was then reached, including 369 members, 179 foreign, 3 honorary, 668 associates, and 37 students.

The Electric Light at Midgley.—Mr. G. Bedford, of Brearley, has made arrangements with Mr. W. Farrar, agent for a firm in Leeds, to have the electric light in his brewery. This mode of lighting is becoming very common in the district.

Military Telegraphy.—It is reported that during the autumn manœuvres of the Belgian army more than sixty messages were despatched in less than half an hour; but all reached their destination promptly and without blocking.

The Paris Institute.—The meetings will recommence on 18th October next, and on the 25th October the annual public meeting of the five academies will be held, under the presidency of M. Eugène Rolland, president of the Academy of Sciences.

Electricity and Submarine Exploration.—In an invention recently patented for facilitating submarine exploration, the oxygen required for supporting respiration is to be produced by decomposing sea water by means of the electric current.

New Telephone.—Mr. John F. Sims has invented a mechanical telephone for facilitating the transmission of sound mechanically, for properly adjusting the strain upon the transmitting wires, and for providing simple and efficient means for signalling.

Electric Light in Schools.—Trials have been made at the Collége Sainte-Barbe and the Lycée Louis-le-Grand, Paris, under the superintendence of the architects, with a view to adopt Edison incandescent lamps with frosted globes for the lighting of the class rooms.

Underground Lines in New York.—The Mayor of New York has refused to sanction the privilege, lately granted to the Commercial Cable Company, to lay down wires in the streets, on the ground that this would give the company right to lay underground pipes in all the streets of the city.

Foochow.—The Great Northern Telegraph Company announce that the steam launch service between Sharp Peak and Foochow has been resumed. Telegrams for Foochow, in code or plain language, can now be accepted to go forward by this service at sender's risk, and at the rate of 8s. 4d. per word.

The Telephone at Leeds.—We have just received the list of the National Telephone Company's subscribers at Leeds. The first telephone was placed in Leeds about October, 1879, and there are now in operation about 300 exchange and 40 private lines. This speaks well for the success obtained at Leeds, and especially so as new subscribers are added daily.

Improved Arc Lamp.—The Rheinische Elektricitäts Gesellschaft has introduced an improvement into its differential solenoid lamps by adding to them a variable resistance, which has the effect of regulating the intensity of the current in the shunt circuit, and a resistance coil, introduced automatically, for compensating the resistance of the lamp when the latter is switched out of circuit.

The British Association in Canada.—A Central News message from Port Arthur, dated 8th September (probably out of telegraph range), states that the Rocky Mountain contingent of members had arrived at that place, but were prevented from proceeding by a storm of wind and rain, which, besides exerting a most depressing effect on the *savants*, had wrecked a bridge and destroyed a portion of the track.

Old Eddystone Lighthouse.—This time-honoured light, a hundred feet high, and massive in proportion, has been transferred from its original position in the Channel to the Hoe at Plymouth as a memorial to its engineer, John Smeaton. The foundation stone of the re-erection was laid by the Duke of Edinburgh a year ago, and on Wednesday last the monument was inaugurated in the presence of 10,000 spectators.

Dynamos for Telegraph Lines.—During the trials recently made at Berlin, with a view to substitute dynamos for batteries on telegraph lines, we learn that the current was supplied by a Siemens continuous-current dynamo working twelve underground and two overhead lines provided with Hughes instruments, eleven underground and twelve overhead lines provided with Morse instruments, and three closed circuit lines.

Telegraphic and Pneumatic Despatches.—The report of the Post and Telegraph Administration of Lower Austria shows for the telegraph department, a net profit of 1,281,292 florins (£128,130) for 1882, and of only 1,013,478 florins (£101,350) for 1883. This falling off is accounted for by a diminution in the number of telegrams, which was 947,814, or 42,040 less than in 1882. On the other hand, the number of messages sent by pneumatic tube has greatly increased.

Electric Lighting at Madrid.—The Sociedad Española de Electricidad, which possesses a large piece of land behind the Ministry of War at Madrid, has lighted that building with Maxim incandescent lamps, and the approach with Gramme and Siemens regulators. The clumps of trees and alleys in the Prado, adjoining, are also illuminated during the fine season by arc lamps placed on candelabra seven metres high, while from the balcony of the Buenavista Palace the electric light is thrown by reflectors.

Electric Discharge in Gases.—Herr Lehmann, in *Wiedemann's Annalen*, considers that the electric discharge in a Geissler tube is always non-continuous, even when the discontinuity is not apparent. A portion of the discharge is effected by convection—that is to say, the air or the gas becomes electrified, and carries the electricity from one pole to another. The electro-chemical action due to electricity, thus accumulated in the gaseous mass, would contribute to give the discharge in the gases the varied forms which it presents.

Second Balloon Ascent at Meudon.—A second ascent was made at Meudon, near Paris, on 12th inst., but this time with by no means the same success as on the first. The balloon rose, but did not return to its starting point, nor answer its helm as on the 9th August. The inventors say, however, that the balloon is not yet perfect, and that the

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wind blew with greater force than that actuating the propeller. M. Chincholle, who appears to have been the only journalist admitted to the School of Ærostation, says that the balloon is not at all like a cigar, but "very like a whale."

THE EXHIBITION AT NEW ORLEANS.—The management of the World's Industrial Exhibition at New Orleans have concluded contracts with various electric light companies for lighting the buildings and grounds of the exhibition. Engines of 1,500 horse-power will be required to drive the electric light, which will cost over 100,000dols. Negotiations are progressing for the construction of an improved elevated electric railway in the grounds. Mr. Burke, the director-general, reports that he will shortly have railway connections into the main building and the Government buildings, and that he will then receive exhibits.

SWIMMING CONTEST OF THE LONDON POSTAL AND TELEGRAPH SWIMMING CLUB.—A large number of Postal and Telegraph *employés* of the eastern, south-eastern, south-western and other districts assembled at the Rotherhithe Baths, on Tuesday, to witness the second annual competition of the members of the East London Postal and Telegraph Swimming Club. There were forty entries for the competition, both senior and junior officers competing. The prizes, a silver cup and numerous sums ranging from £1 to 5s., were won by the officers Beszant, Lynch, Flynn, Woodmansee, Killen, Ruggins, Beek, Taylor, Newman, Leeper, Kemp, and Godfrey.

ELECTRO-CHEMICALLY COLOURED RINGS. — At a recent meeting of the Paris Academy of Science, M. Decharme set up a comparison between electro-chemically and thermically-coloured rings. When a copper plate is exposed to the fixed and narrow jet from an enameller's lamp, iridescent rings are formed on the metal round the point heated; and, under favourable conditions, fixed coloured rings are obtained, which appear unchangeable in the air. These thermic rings are exactly similar to the electro-chemical rings of Nobili; and, like them, they give rise to one another, being propagated in waves. In both cases the colours succeed each other in the same order, which is that of Newton's rings, seen by transmission.

TELEGRAPHIC COMMUNICATION WITH THE EDDYSTONE LIGHTHOUSE. — On Wednesday a deputation from the Plymouth Chamber of Commerce waited on the Trinity Brethren to urge the importance of establishing telegraphic communication with the new Eddystone Lighthouse. The chairman, Mr. Bellamy, said that it was proposed to form a small local company to construct and lay the cable, which would then be worked by Lloyd's Committee, the Trinity Board having full control over it, and being only required to consent to the scheme. The importa nce of such a cable to vessels passing up and down Channel was pointed out, and the Brethren promised to give the matter their earnest consideration.

ELECTRIC LIGHT IN LIGHTHOUSES.—An electric lighthouse has just been completed at the entrance to the Bay of Rio di Janeiro, Brazil. It stands on the island of Raza, and is 85 feet high, resting upon a rock 230 feet above the level of the sea. The light is of 2,000 candle-power, and the current is produced by a Gramme machine, worked by a stationary surface-condensing steam engine. All the fittings are double, to prevent unforeseen accidents; and in view of the possibility of a double accident, an oil lamp is always kept in readiness for use. The light is a revolving one, with one red and two white discs succeding one another at fifteen minutes' interval, and the light is visible at about 35 miles distance.—*Sanitary Engineer.*

DISTRIBUTION OF CURRENT IN NEW YORK.—Last week we referred to the arrangements being made by the New York Steam Company to supply the public with electric current as well as steam. In connection with this subject, we learn that the steam supplied by this company is used, in many cases, to run dynamos for electric lighting. The new Mutual Life Assurance Company has steam laid on by a 6in. pipe, for heating the building, working the lifts, and running the dynamos for 1,800 electric lights. As by far the larger proportion of steam used for other purposes than electrical lighting is not required at night, electric light can be furnished direct, at very low rates, from this company's own dynamos, by utilising the surplus steam.

ELECTRIC LIGHTING OF THE STOCK EXCHANGE.—The contract for lighting the new and old buildings of the London Stock Exchange has been entrusted to Messrs. Woodhouse and Rawson, of 11, Queen Victoria-street, E.C., and the work is to be proceeded with at once. This firm has other contracts on hand, among which may be mentioned Messrs. Guinness's Brewery, Dublin; Messrs. Ambuhl, Loebel, and Co.'s, Hamburg, and Messrs. Keyser and Co.'s, Cornhill. They have also the following private country residences to light:—Gortmore House, Dundrum, Co. Dublin, the residence of E. G. Burke, Esq.; Paddockhurst, Worth, Sussex, belonging to Robert Whitehead, Esq.; and Colonel Freemantle's residence, The Chuffs, at Maidenhead.

THE TELEPHONE IN FRANCE.—Since obtaining a prolongation of its concession for five years the Société Générale des Téléphones has been studying several important improvements demanded by the subscribers, who will ere long be put in communication with the telegraph system, so as to receive and transmit their messages direct. In conjunction with the company, the Minister of Posts and Telegraphs is arranging for a number of public telephone offices to be started in connection with the system. The *Bulletin de la Compagnie Internationale des Téléphones*, from which we cull the above information, says that a number of business men who are in frequent relations with notaries contemplate boycotting, or at any rate sending to Coventry (*mettre en interdit*) those members of the cloth who do not place themselves in telephonic communication.

THE OLDEN TIMES.—*Apropos* of Oliver Wendell Holmes, the following story is authentic:—In the early heroic days of ocean telegraphy—at a time when, although great difficulties had been encountered and a connection had at last been successfully established, the discouragement of many failures still hung over the undertaking—a triumphant dinner took place, to which prominent Englishmen and Americans, among others Dr. Holmes, were invited. The poet was unable to come, and in his absence his health was drunk and the fact communicated to him at Boston by the new submarine wire. Dr. Holmes sent in reply the following prompt and grateful message:—"You send me a message *de profundis.* I reply *sursum corda.*" It is said that the electricians were a little puzzled by the Latin, but that Mr. Cyrus Field, who was present, and who is never at a loss, set them right.

THE EARTHS'S MAGNETISM.—Under this head we recently (13th inst.) described the six subterranean chambers constructed at the Paris Observatory for studying the earth's magnetism. The greatest difficulties met with are those connected with damp and ventilation. The former is combatted by means of lime and sulphuric acid; and a gas stove, combined with ventilating shafts, will counteract any efflorescence on the walls. All the scientific instruments will be preserved

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from oxidation by being coated with special substances, so as to permit of observations being commenced before the walls are quite dry. It will be *de rigeur* not to admit any object whatever made of iron, as that would influence the magnetic needle. These subterranean chambers are not the deepest in the Observatory. Those that approach the nearest to the catacombs contain the central clock, that which regulates all the pneumatic clocks of Paris.

RAPID TELEGRAPHY.—As a feat in telegraphy (says the *Melbourne Herald* of the 1st August) the shortness of the time occupied in the transmission of Reuter's telegrams announcing the result of the Goodwood Cup, run in England yesterday, may be mentioned. The race was run at three o'clock in the afternoon, Greenwich time, and the telegram was despatched from London at 3:17 p.m. It reached the office here at 2:50 a.m., Melbourne time, and was published in this morning's papers. Allowing the 9 hours 40 minutes which Greenwich is behind Melbourne in point of time, this makes the actual time occupied in transmission from one end of the woıld to the other 1 hour 53 minutes. This message probably came through more quickly than any message previously transmitted either way, and is regarded as the "best on record." The message sent by the Marquis of Normanby to the Queen and the Prince of Wales announcing the opening of the Melbourne International Exhibition occupied about three hours longer in actual transmission.

PROTECTION AFFORDED BY OVERHEAD WIRES.—During a recent thunderstorm at Minneapolis, the drill hall at the State University was struck by lightning, when a series of electric lamps were lighted and as suddenly extinguished. A loud report followed; and balls of fire were seen following the wire away from the building, where four thousand persons were assembled. The fine wire circuit for maintaining the lamps was afterwards found to have been fused. On the other hand, we learn from the *Western Fireman* that, at Louisville, during a gale of wind, an arc light wire crossed a fire-signal wire, which carried the full force of the current to the central fire-alarm station. In an instant the room was ablaze with a blinding and intensely hot light, followed by total darkness. Investigation showed that about three hundred alarm boxes had been wholly or partially destroyed; so that, in addition to the monetary loss, notices of fire breaking out in the city have to be sent by messenger, failing a telephone.

SPECTACLES FOR THE ELECTRIC LIGHT.—Dr. W. H. Stone, F.R.S., who recently read a paper on the Physiological Bearing of Electricity on Health, at the International Health Exhibition, on the occasion of the conference held there by the Society of Telegraph Engineers and Electricians, has devised a pair of spectacles or eye protectors for persons who are in the habit of working by or with electric light. The spectacles consist of front glasses of blue with attached side glasses or "blinkers" of red glass. The danger to the eye from the incandescent lamp is likely to arise from the red or heat rays, that from the arc lamp is due to excess of blue or actinic rays, hence the use of two glasses. In looking at the incandescent light through the blue glasses the glare is removed, and irritation from the intense yellow and red rays prevented, while after folding down the red side glasses over the blue front ones, the arc light can be looked at with safety through the joint media. The tints of the glasses are selected and combined by the help of the spectroscope.

METALLURGY CLASSES AT KING'S COLLEGE.—The syllabus of the metallurgical evening lectures in Professor Huntington's department is now published. There is to be a course of lectures, from 8 to 9 on Monday evenings, on the Properties of Metals and Alloys and their Uses in the Arts (which is intended to be of assistance to candidates for the examination of the City and Guilds of London Institute), in Metal Plate Work, Plumbing, and Iron and Steel; another course, from 7 to 8, on the same evening, by Mr. W. G. McMillan; the Demonstrator in Metallurgy will treat of Fuel and its Applications, and will include the subjects required for the Institute's examination in Fuel. The laboratory for practical work, besides being open on Friday evenings from 7 to 9, will be available as usual every day during college hours (from 10 to 4, on Saturdays 10 to 1) for "occasional students, and for those who are passing through the college engineering course." The first lecture will be on the 6th October. We are glad to find that the fees are to be reduced this year for the evening classes.

THE TELEPHONE ON THE CONTINENT.—The use of the telephone is generally on the increase in most parts of the Continent, the subscription in France being at the rate of 200f. (£8) per annum, reduced to 170f. when there are over 300 subscribers. The manufacturing towns of Lille, Roubaix, and Turcoing are now in communication, the average number of messages per day between the two latter places being 657; and the system is in force also at St. Quentin and Troyes. Rheims is the best served town in France for its size, and contains 210 subscribers, or 23 out of every 10,000 inhabitants. This is the highest number comparatively in the whole country, Paris, Lyons, and Bordeaux having but 14 to every 10,000; Calais and St. Pierre, 22; Havre, 18. The total number of French telephone subscribers is 5,535, while Germany has only 4,000 in 21 cities and towns. The proportion at Berlin is nine to the 10,000 inhabitants, Vienna four, and Brussels 11. Munich has 393 subscribers, Leipzic 285, and Chemnitz 101. A system has just been inaugurated at Mons, in Belgium, so that the inhabitants of the Borinage coal district may converse with Brussels, Antwerp, Charleroi, Liége, and Verviers.

MILL LIGHTING BY ELECTRICITY.—The Park-lane Twist Company, Preston, have undertaken an improvement in their mill, which must prove a great advantage in many ways. They have decided to fit up the greater portion of the buildings with the electric light, which has been successfully carried out by Mr. Frederick D'A. Goold, of the "Volta" Electrical Works, Manchester. This is the first mill in Preston, we believe, in which the light has been introduced, and all concerned seem to be well satisfied with the results. There are 65 lights of 16 candle-power; 24 are in the lower reeling room, 22 in the upper reeling room, 10 in the carding room, and nine in the chapel reeling room. The dynamo machine which regulates the current is worked by an electromotive force of 90 volts. It is contended that in the great majority of cases there is an ample surplus of power in large works to drive all the machinery necessary for the production of the electric light, thus minimising the cost for maintenance, and under these conditions insuring a far superior and more healthy light at a less cost than gas. The light is said to be more brilliant, cheaper, and safer in a room where so much "fluff" is continually flying about.

VARIATION WITH THE TEMPERATURE OF THE RESISTANCE OF BISMUTH AND ITS ALLOYS.—In some notes on this subject, M. A. Leduc remarks that, contrary to bismuth, the resistance of which increases about four thousandth parts for every centigrade degree between 12 and 60 degrees C., the resistance of an alloy of bismuth and lead of equal weight increases about

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one and a half thousandth parts under the same circumstances. In the hope of finding an alloy the resistance of which should not vary appreciably between rather considerable limits of temperature, he combined one equivalent of lead with two, three, four, and five equivalents of bismuth successively, and obtained wires of these alloys by causing the liquid metal to rise in glass tubes. The resistance of all increased (between 13 and 8 ten-thousandth parts) on the temperature being raised. He again tried commercially pure bismuth, made into a wire by the above-named methods, when the resistance increased three thousandth parts of its value per degree. The remarkable difference between this wire and the band before experimented upon is believed to be due to the method of their preparation and the very different speed of their cooling. M. Leduc remarks that pure bismuth and the last alloy experimented with considerably increase in volume on solidifying, and in this case finds an exception to the rule regarded as general that "for metals which increase in volume on solidifying, the resistance diminishes on the temperature being raised."

COMPETITIVE TRIAL OF ELECTRIC LAUNCHES.—The trial trips of the "Australia" and the "Electricity" came off successfully on Saturday last. The boats started from the wharf of the Storage Company, Millwall, at 1:55, reached London Bridge at 2:20, Blackfriars at 2:25, and Charing-cross at 2:32, the "Australia" being very slightly in advance. The "Australia" was propelled by a Reckenzaun motor, weighing 390lb., and taking a current of 37 amperes from 50 E.P.S. accumulators placed at the bottom of the boat. Eight passengers were carried, the E.M.F. being 100 volts. The screw propeller of the "Electricity" was worked by a Siemens D2 machine, weighing 658lb., and 40 E.P.S. accumulators of a larger and heavier type than those of the "Australia." The motor took 47 amperes, the E.M.F. of the cells being 80 volts. There were seven passengers on the up journey, and eight on the down. Part of the way there was a strong wind, with tide against the boats. The return journey from Charing-cross commenced at 2:40. There was a ten minutes' stoppage off the Tower to cool and slacken the gland of the "Australia's" stern tube, and another stoppage about the same period at Millwall to bale out a quantity of water which had been shipped by the "Electricity" on passing some large steamer. Greenwich Pier was reached at 4:10, both launches arriving at the same time; and they cruised about on the river until 6 p.m. On the "Electricity" were Mr. J. J. Courtenay and Mr. Thornton, of the Storage Company, Mr. Simpson, of Siemens Brothers, and others; and on the "Australia," Mr. Stephens, Lieut. Robinson, R.N., H.M.S. "Vernon;" Mr. A. Reckenzaun, C.E.

THE HOCHHAUSEN SYSTEM.—In our announcement last week of the practical contest between the Toronto Electric Light Company and another company, which resulted in the bestowal of a five years' contract with the former, it is right to explain that the system used in America under the name "Excelsior" is identical with the Hochhausen system. This is in the hands of the firm of Messrs. Edmunds and Goolden (late Henry Edmunds, jun.), of 2, Victoria-mansions, Westminster, who have recently established and fitted up a factory at Halifax, Yorks., for the manufacture of the Hochhausen dynamos and lamps, and other electrical apparatus. Messrs. Edmunds and Goolden acquired all the patterns and drawings of the Gramme dynamos at the sale of the effects of the late firm of Emmerson and Murgatroyd, who were the sole makers of that machine in this country, together with a large number of complete Grammes and armatures, &c. Mr. Edmunds is, moreover, intimately connected with the firm of Armington and Sims, and has just made arrangements for the manufacture of the well-known Armington and Sims engine by one of the leading firms of engine builders in the Midlands. We are informed that Mr. Edmunds is at present making similar arrangements on the Continent. The name "Excelsior" is retained only in connection with the carbons. This firm has several important domestic installations in hand near London, together with several mills and factories in the North. Several of the leading shops in Halifax are lit by electricity from their factory, with the result that a powerful Armington and Sims engine is, we believe, being erected for this purpose to meet the applications for light in the town.

SHIP LIGHTING.—The paddle steamer "Saturno," built by Messrs. A. and J. Inglis, of Glasgow, a magnificent saloon vessel (300ft. long, 60ft. broad), for service on the River Plate, has been lighted throughout by Messrs. W. Harvie and Co., of Glasgow, the well-known ship lamp patentees, who have secured a license for the manufacture of the Elphinstone and Vincent dynamo-electric machine. The installation consists of 320 Swan lamps of 20 candle-power. Each of the three decks has two separate circuits, one for lighting the passages and centre lights of saloons, and lights required all night, the other for state rooms and table lights of saloons. Each state room has a separate lamp and switch, and the saloons are also controlled independently. There are six circuits on the main switch-board, each controlled by a double contact switch to ensure good connection, also a fusible plug. Close to the main switch-board is an adjustable resistance in the field magnet circuit, and an Auld's reducing valve for controlling respectively the electromotive force and speed of the dynamo. The current is supplied by an Elphinstone and Vincent dynamo, size E, for supplying 400 20-candle-power lamps. The steadiness of the light and general good working of the machine were much appreciated by the owner and builders of the vessel, and also by a large party of visitors, to whom it was exhibited before proceeding down the Clyde. The machine used is in every respect similar to that now working at the International Health Exhibition, where it is lighting numerous stands, &c. The circuit is continuous, and of low tension; the terminals, or any of the wires, may be held in the bare hand without inconvenience whilst the machine is giving its most powerful current.

THE ELECTRIC LIGHT ON BOARD SHIP.—Last week an important trial was made, at the instigation of the Admiralty, at Portsmouth, having reference to the practical utility of the electric light for side lights and mast-head lights on board Her Majesty's ships. The following gentlemen were present: Captain Carr, H.M.S. "Crocodile"; Captain Douglas, H.M.S. "Serapis"; Captain Dyer, H.M.S. "Sultan"; Mr. Marshall, Assistant-Constructor, Portsmouth Dockyard; and other naval and dockyard officials, together with Mr. Lane, the electrician, Portsmouth, and the Edison and Swan Company's engineer. After arranging to place 50 candle-power Edison lamps in the ordinary port, starboard, and mast-head lanterns of H.M.S. "Crocodile," and an ordinary oil light on the South Eastern Railway Jetty, alongside which the "Crocodile" is lying, as a standard to compare the electric light with, a launch, which was used in making the trial, proceeded to the "St. Vincent" training ship, a distance of about a mile, the electric lights showing up in a most brilliant manner; and here a signal was made to the "Crocodile" to substitute 16 candle-power Edison lamps for the 50 candle-power Edison lamps, the oil lights remaining the same. Naturally the result of this was to diminish the effect, but it enabled a little more careful comparison to be made between the electric light and

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the oil. When the 50 candle-power lights were in, the difference was so great that no fair comparison could be made out; with the 16 candle-power lamps in, the electric light appeared approximately to be twice as bright as the oil. The launch then steamed about another mile further off, until she came abreast of the Clarence Pier, when, owing to a slight haze, the oil light became invisible, while the electric light was still well in sight. The result of this trial was that the officers and other gentlemen present expressed their complete satisfaction as far as the illuminating power was concerned; and we believe it is confidently expected that the Admiralty will now generally adopt the use of electric signal lights on board the ships fitted with the necessary plant; and as the prejudice against the use of incandescent lamps for signal lights has been and still is of a rather determined nature, we trust that this trial made by the Admiralty, and the opinion that they have come to, will materially help in reducing the prejudice alluded to, and that we shall before long see all our large mercantile ships using electric signal lights.

THE E.M.F. OF AMALGAMATED ZINC.—In a note on this subject by M. G. Lippmann, in the *Journal de Physique*, he observes that generally a greater E.M.F. is attributed to amalgamated than to pure zinc. If a plate of each of the two substances be immersed in a sulphate of zinc solution, a couple is formed in which the amalgamated zinc forms the negative pole, inasmuch as it is the more readily acted upon by oxygen. Such, at least, is the result obtained if special precautions be not adopted. In a recent work M. W. Robb shows that, if care be taken to use pure zinc obtained by electro-deposit, and also sulphate solutions which have been deprived of all free acid by remaining on carbonate of baryta, the element will not manifest any appreciable E.M.F. The negative result obtained by M. Robb may be confirmed by the following line of reasoning, founded on Carnot's principles. If the zinc and amalgamated zinc couple had a fixed E.M.F., it might be possible, by closing the circuit, to cause the current to produce some definite mechanical work. On the other hand, since the amalgamated zinc behaves as the metal attacked, the effect of the current is to get rid of the amalgam, separate the mercury, and tranfer the zinc which it contained to the surface of the pure zinc. In this way, at a very small cost, the couple might be regenerated by collecting the zinc thus deposited and conveying it mechanically to the mercury side, where it would again become amalgamated; in fact, definite quantities of work might be produced while only expending the insignificant labour of transferring the zinc by hand. Now this would be incompatible with Carnot's principle. Not that it would be incompatible with the principle of equivalents, for the amalgamation of zinc produces cold, so that the heat absorbed by this amalgamation might be the exact equivalent of the work done. This is even, as explained by M. J. Regnault, the working of the element by the dis-amalgamation. But, according to Carnot's principle, the transformation of heat into work can only take place if there be a simultaneous passage of the heat of a hot body into a cold body. In other words, it is not possible to construct an apparatus which produces work on the simple condition of producing an equivalent quantity of cold. Now the zinc and amalgamated zinc battery would be precisely a case in point. On the other hand, the cadmium sulphate pole of the cadmium and amalgamated cadmium element manifests an appreciable E.M.F. The pure cadmium is dissolved and transferred by the effect of the current to the amalgamated cadmium. In this case, the above line of reasoning cannot be adopted; and Carnot's principle is no longer applicable. This pole cannot, in fact, be regenerated except by depriving the cadmium of its amalgam. Now, this operation cannot be performed mechanically; and to be effected electrically, it would require an expenditure of power at least equal to the production of the work due to the current.

NEW ZINC ACCUMULATOR.—One cannot help being a little amused at the way in which inventors are continually ringing the changes on secondary battery arrangements. M. Reynier has lately devised a zinc accumulator, which has, to use the usual formula, given good results. It comprises four large Planté positive electrodes, bent and perforated, and three negatives, consisting of smooth lead plates, which are coated with zinc by electro deposit from an acidulated solution of sulphate of zinc, in which the element is immersed. Glass tubes attached to the negatives by lead wires prevent accidental contacts inside the battery. The seven electrodes are carried by as many separate cross bars, made of paraffined wood, which rest on the edges of the cell, and keep the plates at a certain distance from the bottom. The place of a cover is taken by these cross bars, which touch one another. Each plate is provided with a terminal, the four positive poles being on one side and the three negatives on the other; and two brass rods, terminating in binding screws, connect the poles of the same name. The cell consists of two wooden rectangular boxes, one inside the other, with a space of several millimetres between, lined with a watertight cement, supple and non-conducting, of tar base. The complete insulation of the case, and of all the parts, the purity of the metal deposited, and its amalgamation, are said to reduce to a minimum the local attack on the zinc, which was considerable in the old Nantua battery. The consequence is that what is called the *co-efficient of restitution* may now be compared with that of the Planté accumulators. The following are the leading particulars of the new accumulator:—

E.M.F.	2·36 volts.
Mean resistance	0·02 ohm.
Normal intensity of discharged current	25 amps.
Intensity of charged current........................	5 to 10 „
Capacity of accumulation after 200 hours of formation	550,000 coul.
Effective surface of the four positive electrodes ....(3,100 sq. in.)	200 dm².
Effective surface of the three negative electrodes ....(2,015 sq. in.)	13 „
Weight of positive electrodes ....(18lb.)	8·2 kg.
„ negative electrodes ....(3lb.)	1·4 „
„ the cell ....(6lb.)	2·7 „
„ the fluid ....(10lb.)	4·4 „
„ the lead wires ....(1lb.)	0·46 „
Total weight ....(38lb.)	17·16 „

The total amount of electrical force stored up is 130,000 kilogrammetres (950,000 foot-pounds), or 7,600 kilogrammetres (55,000 foot-pounds), per kilogramme (2·2lb.) of accumulator. Theoretically, a zinc accumulator should store up double that amount; and if this form gives less, it is—at least so is said in *Les Mondes*—because M. Reynier has designedly increased the strength of the cell and the bulk of the electrodes beyond what is necessary. It should also be remarked that this capacity of 7,600 kilogrammetres per kilogramme is higher than that of any accumulator hitherto made in France. Therefore, notwithstanding the great weight of the cell and the positives, this new form of accumulator is relatively light, which renders it suitable for use in electric locomotives as well as in fixed plant. Independently of their use as accumulators, zinc secondary batteries may be utilised as "regulating voltameters" in incandescent lighting, and for counteracting irregularities due to the piston stroke, accidental stoppages, and other causes.

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THE PHILADELPHIA EXHIBITION.—I.

(FROM OUR SPECIAL CORRESPONDENT.)

PHILADELPHIA, SEPT. 11.

Although the Electrical Exhibition has been open for ten days, it is not yet ready to be reported in detail. The exhibitors have been hard at work since the opening, but work is still going on, and even the completed displays suffer from the confusion that surrounds them. For the present, therefore, I can give you only a general idea of the Exhibition, reserving description of particular exhibits for future letters.

The building erected for the display is irregular in form. The main hall is rectangular, 100ft. by 200ft. in size, with a Gothic roof span springing from the ground. A gallery extends all around this hall. A large annexe, triangular in shape, and with a low roof, completes the structure, except that at each corner there are towers two and three stories in height, where the offices, committee, Press, and other rooms are situated. The building is roughly built of wood and glass, and is little better than a shed, although made somewhat picturesque in appearance by its numerous towers. Directly opposite the Exhibition hall is a large brick structure formerly used as a depôt by the Pennsylvania Railway Company. This was put at the disposal of the Franklin Institute, under whose auspices the Exhibition is held, and is now connected with the main building by a bridge spanning the street. In the railroad depôt there is a museum of apparatus of historical interest, including many original inventions contributed by the Patent Office and various institutions of learning. Here also is a large hall used for lectures and concerts, a restaurant, &c. In the open area adjoining the depôt the larger exhibits of electrical railroad switches, signals, &c., are erected. A boiler house adjoins the main hall, and there are several locomotive boilers employed to furnish steam stationed in the open ground near he building.

In the centre of the main hall a fountain was erected which, besides the usual central sprays rising from rockwork, has a number of streams converging on the rockwork from the outer circle of the pond or tank. Back of each of these streams there is an electric light, whose rays are directed by lenses along the axis of the stream. They are thus rendered invisible until refracted from the spray where the water breaks against the rock. The effect is very beautiful, especially when various coloured lights are used. The fountain, however, like many other things, is not yet in perfect working order, and is usually shown with coloured lights thrown directly upon it from locomotive head lights. The fountain occupies the centre of the hall. Ranged about it are the very fine Government exhibits, a miniature telephone station, Delaney's synchronous multiplex telegraph exhibit, and various exhibits of philosophical apparatus. All along the boiler-house side of the building are ranged the dynamo machines, of which there is a large display, though no great variety of models. There are two large exhibits of electric lights in the main hall, but nearly all the lights and motors are shown in the triangular annexe on the side of the building opposite to the boiler-house.

There is also a general display of arc lights in the main hall, each of a dozen arches carrying about nine or ten lamps. The illumination, however, is not remarkable, the lamps being suspended from 40ft. to 60ft. above the floor.

The power employed for driving the machinery is 2,000 horse. There are about 1,000 arc and 5,000 incandescent lamps in and about the building, and 100 or more motors, most of the latter being small in size. Several gas engines are also employed to furnish power for driving dynamo machines.

Several exhibitors have erected within the building small furnished rooms in which to display methods of domestic lighting, but they are cheaply constructed, and do not have a very good effect. A large organ in the main hall is operated by electricity, and an enterprising clothier shows a complete working establishment, with sewing machines operated by electric motors. There is also a printing press run by the same power, and on which the regular edition of the *Electrical World* is printed.

The Exhibition is quite attractive to the public, but contains very few novelties to the electrician. Its most interesting features to professional men are the personal exhibits of Weston, Edison, and Thompson, and the historical museum. In these displays one is enabled to see how discoveries have been made and what is the process of invention. Edison has a remarkably fine display, covering the whole range of applied electricity.

The Conference of Electricians, called under Government authority, has been in session during the week, but has thus far done little more than discuss questions relating to electrical units and the action that should be taken by the Government in establishing standards of measure for public use. It is probable that before the week is ended definite action will be taken on these subjects. A long discussion was held to-day on the theory of dynamo machines, which developed serious disagreements between the doctors. Of this I shall send you an account as soon as the debate has taken definite shape.

It is quite likely, however, that the reports of the Board of Examiners now in session will prove of more value and interest to electricians than the Exhibition itself, or the conference mentioned above. A very capable Board has been appointed, which has been divided into committees, each of which is making exhaustive tests of apparatus submitted to the Board. No medals are to be given to exhibitors, but a more valuable prize for some of them than any medal could be will be the report of the examiners. I do not suppose that any of these reports will be made public until after the Exhibition closes, and it is quite probable that some of the tests will be continued beyond the six weeks allotted to the Exhibition.

The weather has been excessively warm ever since the Exhibition opened, the thermometer marking from 85 to 95 degrees each day. Although this interferes to some extent with the Exhibition, the attendance has nevertheless been quite good. Next week, when the exhibits are all in order, and the weather has improved, the hall will probably be crowded every night.

ELECTRIC LIGHTING OF THE IRONCLAD "RICHELIEU."*

The use of electric lighting on board men of war has been generally adopted for night searches by means of projectors; and a few Powers, including England, France, Italy, and Austria, have applied electricity to the internal lighting of several war vessels. In most cases, incandescent lamps have successfully stood all the tests of practice. They give a very agreeable light, while, at the same time, simplifying the electric illumination and preventing any chance of fire. They also permit of increasing the power of the side lights, and of giving night signals with as much safety as rapidity. The advantages of electric lighting have been recognised by the principal companies of the merchant marine; and the recent application made by Messrs. Sautter, Lemonnier, et Cie., on the French ironclad "Richelieu" have proved that the same is the case for the navy; but in this case, the conditions to be fulfilled being more numerous and essentially different, it was necessary to devise and apply a combination of new arrangements.

The Gramme dynamo-electric machine, which maintains 211 incandescent lamps of 8 candles each for the internal lighting, and 16 of 30 candles each for the head lights, the side lights, and the signals (as shown in Figs. 1 and 2), yields a current of 200 or even 250 amperes. With a normal speed of 580 revolutions, the E.M.F. at the terminals is from 51 to 52 volts; and the internal resistance does not exceed 0·008 ohm. The electro-magnets are excited in shunt circuit by a current of 22 amperes.

The distinguishing characteristic of this machine consists in the fact that it has a constant E.M.F. at the terminals, whatever be the number of lamps in the circuit. The armature coil consists of 100 copper bars, forming a cylinder of 180 mm. (7in.) diameter, insulated one from another by cardboard dipped in Jews' pitch. The ends of this cylinder (Figs. 1 and 2) are turned so as to form the collectors *c c*, on which rest the brushes *j j*.

* Reproduced from the *Revue Industrielle*, to the editor of which we are indebted for the illustrations.

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formed of silvered copper wires. At a distance of 75 mm. (3in.) from each of these, spokes, *d d*, are sunk in semicircular recesses, and fixed to the bars by two copper rivets and a tin solder joint. The cylinder *a* is covered on its outer surface by a layer of insulating cloth, on which is rolled the iron wire for forming the soft iron core *b* of the coil, and which is itself insulated with cloth. The coil is connected with the steel shaft *l* by means of eight iron keys; it terminates in copper bars, *e e*, of trapezoidal section, the two ends being recessed into each of the spokes, to which they are fixed by a solder joint. Care is taken to mount the two ends of the spokes, butting on two successive bars, so as to form a helicoidal coil. These external bars are insulated from each other by bands of cardboard; and the whole is encircled by cloth covered with brass wires soldered.

The electro-magnets are formed of eight round iron bars, *f f*, 0·8 metre (about 3ft.) in diameter, connecting the base *g* of the machine with the upper plate *h*, and carrying in their middle the cast-iron poles *i i*. These soft-iron columns are transformed into electro-magnets by the current of the shunt circuit, which traverses the copper wire surrounding them. The wire has a diameter of 44 tenths of a millimetre; and the length rolled upon each half column is 83 metres (272 feet). The coiling is so effected that the consequent points of the electro-magnets are formed on the armature itself, as in all Gramme machines. The poles *k*, whence the current is taken off, are

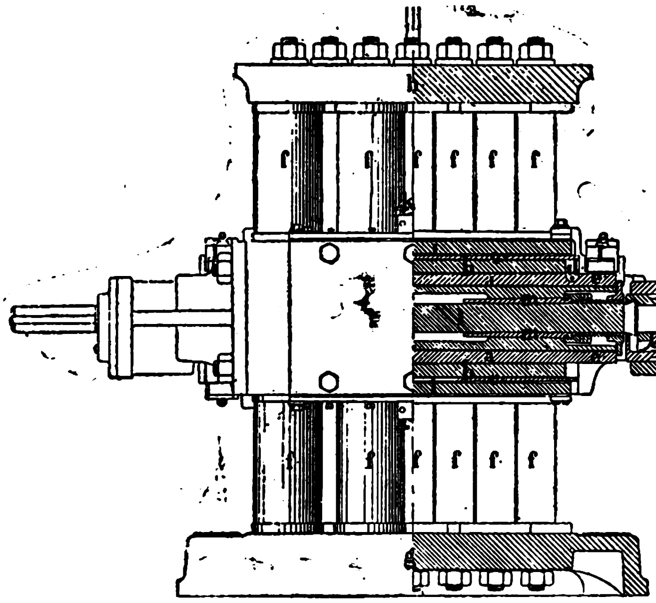

Fig. 1.

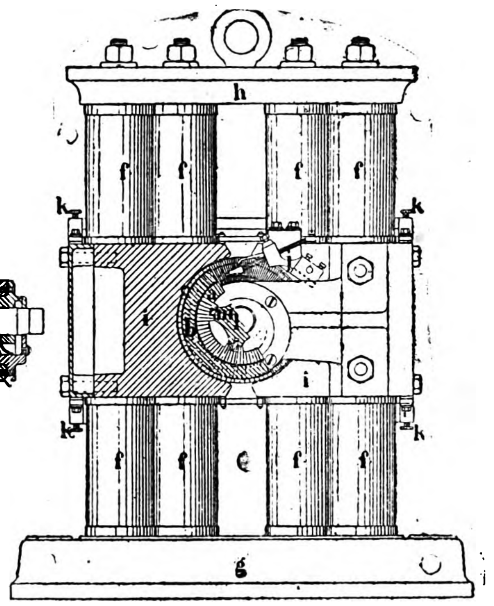

Fig. 2.

placed right and left, for facilitating the departure of the circuits.

The machine, thus constituted, is very strong. At a speed of 580 revolutions it absorbs 25 horse-power, while maintaining 400 lamps of 8 candles, or 200 lamps of 16 candles; but this speed, rather high for a direct-acting motor, may be, without inconvenience as far as the dynamo is concerned, increased to 900 revolutions. The E.M.F. and the effort absorbed are thus practically doubled; and 800 lamps of 8 candles, or 400 lamps of 16 candles may be maintained. Notwithstanding its power, this machine occupies but little room, less than a square metre of base, and about a metre high. When run at low speed, it is very suitable for lighting war vessels, because it remains considerably below its maximum degree of production, which ensures a long duration of service.

The 227 Edison lamps fixed on board the "Richelieu" have been divided into seven circuits, as follows:—

1.	Day circuit	68 lamps of 8 candles.
2.	Night circuit	79 lamps of 8 candles.
3.	Fighting circuit	16 lamps of 8 candles.
4.	Engine circuit	22 lamps of 8 candles.
5.	Sea circuit	22 lamps of 8 candles.
6.	Side-light circuit.........	6 lamps of 30 candles.
7	Signal circuit	10 lamps of 30 candles.

All these circuits constitute the main divisions of the installation, and respond each one to a special requirement of the service. 1. The day circuit is maintained day and night; it illuminates the lower portions of the vessel, which are dark even during the day. 2. The night circuit lights the berths, cabins, &c. 3. The fighting circuit serves the ammunition bunkers. 4. The engine circuit permits of walking round and inspecting the various parts of the engine, and doing repairs. 5. The sea circuit completes the illumination of the engine and boilers when at sea. 6. The side-lamp circuit includes three lamps astern, two side-lights, and one head-light in the top. 7. The signal circuit maintains the lights placed on the masts during the night.

For the different circumstances in which the vessel may be placed, the lighting has been provided for in the following manner:—

In port during the day	94 lamps
In port during the night...............	171 "
At sea by day	116 "
At sea by day and fighting............	132 "
At sea during the night	211 "
At sea during the night and fighting	227 "

All the lamps excepting the head lights, the side lights, and the signals, are Edison B lamps of 8 candles, requiring 50 volts and 0·75 ampere.

They have been fixed to brackets, the form and arrangement of which vary with the places to be lighted; but, throughout, special precautions have been taken for counteracting the

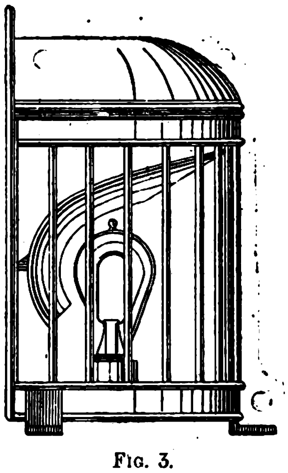

Fig. 3.

vibration due to the engines, and to the shocks caused by firing. With this object, a felt washer from 10 to 15 mm.

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(⅜in. to ⅝in. thick) has been interposed between the sides of the vessel and the point where each bracket is fixed; secondly, each lamp is connected with its bracket by two small wood sockets and spiral springs, an arrangement which considerably deadens the shocks. In all the berths and places for the crew the lamps are enclosed in lanterns, which can only be opened by special triangular keys.

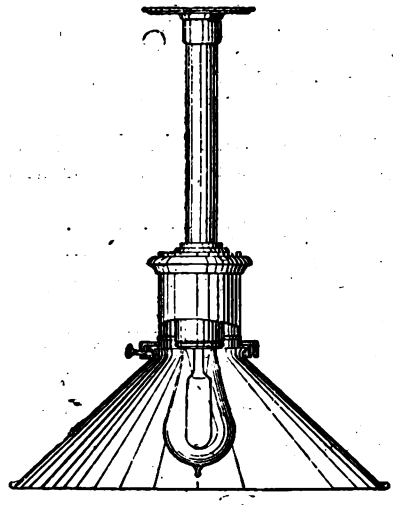

FIG. 4.

The lamp, shown in Fig. 3, lights up the gun battery and the berths. A few places have required the use of movable lights, which are, for this purpose, suspended by three small chains (Fig. 6). Thus, in the officers' state rooms and

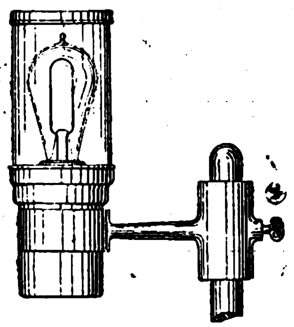

FIG. 5.

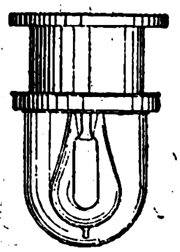

FIG. 6.

cabins the brackets have the form of an arm (Fig. 7), or a straight pendant (Fig. 4), which are very similar to the ordinary forms used with candles. All these appliances are nickelised or tinned; and the lamps are provided with opal

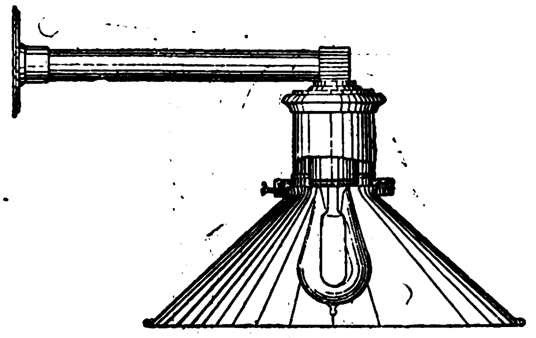

FIG. 7.

shades. The cabin of the petty officers is provided with similar fittings simply bronzed, and with tin shades. Similar types are fixed in the engine room; and Fig. 5 shows the manner in which the lighting of the pressure gauge and water-level of each boiler is effected. Lastly, the type shown at Fig. 8 is very suitable for the bunkers and passages.

The seven circuits enumerated above start from a switchboard (Fig. 9) placed near the electric machine. Each one is worked by a switch, which permits of turning on or extinguishing the light, on the word of command being given by the officer in charge. Moreover, in each circuit a certain number of lamps are provided with separate switches, having special keys.

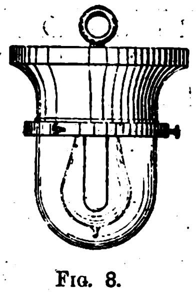

FIG. 8.

The leads, which are perfectly insulated, have been laid on boards fixed to the sides of the vessel, or passed through metal pipes; and, after laying, they were protected by being covered with wood. Forty-eight cut-outs divide the installation into as many groups of lamps, in such a manner that, if accidentally the wires of any one lamp should come into contact, the whole group controlled by the corresponding cut-out would be automatically switched out of circuit.

The four first circuits have a common return wire, which terminates at the switch-board in a single commutator; and the two other circuits, 6 and 7, which are more exposed to damage, have a special return wire, bearing a notice to this effect on the switch-board. It is therefore always possible to separate completely the wires of these circuits from the rest of the arrangement.

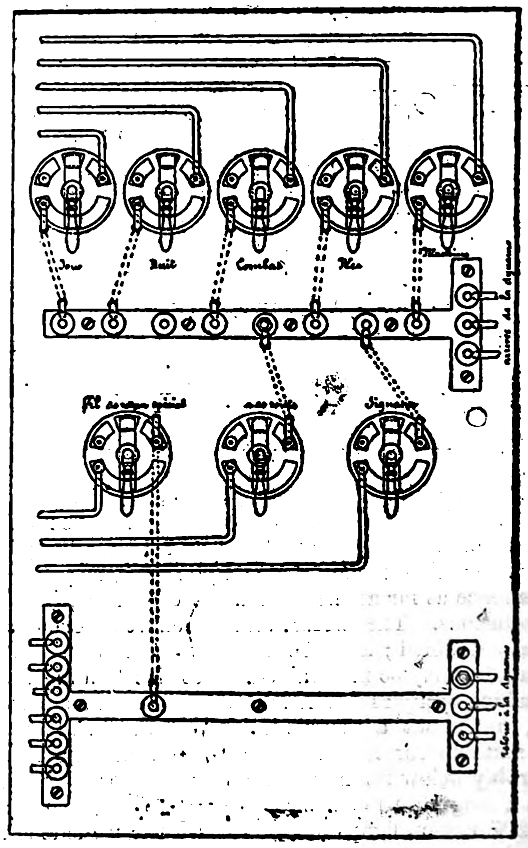

FIG. 9.

Consequently, the areas of the conductors have been calculated, and the starting points of the principal shunt circuits chosen, so that, in each circuit, the differences of potential between the two wires of the furthest lamp do not differ by more than one volt from the diminution at the switch-board. As, on the other hand, the fall of potential at the terminals of

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the machine is practically constant, the total intensity of the current is always proportional to the number of lamps in incandescence. There is therefore no need of any regulation at the time of lighting, or extinction of one or more circuits. It is sufficient to turn the corresponding switch on the switch-board, always leaving a few minutes' interval between working two switches, so as to allow the governor of the steam engine time to regulate the speed. The apparatus, which permits of working the necessary changes for the signal lights with as much rapidity as precision, consists in the production of a luminous *schema* before the commutator, even of the lamps placed on the masts.

Messrs. Sautter, Lemonnier et Cie have devised a method which may be employed in arranging a system of electric lighting on board a war vessel, by which, without differing too much from the arrangements described above, it would be easy to work a projector by a group of machines identical with those connected with the internal illumination. One of these groups might provide for the illumination of lamps constantly lighted, and the other be held in reserve both for the projectors and for the internal lighting. It would also be possible, by means of very simple arrangements, to utilise the available currents for the transmission of motive power to certain portions of the vessel—to the repair shop, for instance. In brief, this project would consist in establishing, in a very restricted space, a central station for the production of electricity, which might be utilised for the internal illumination, for the projectors, for the maintenance of arc lamps, for embarking and disembarking, and, lastly, for the transmission of motive power.

It is certain that the progress made in electricity permits of practically carrying out these different applications.

ALBERT MARNIER.

KETTELL'S ELECTRIC CLOCK SETTING MECHANISM.

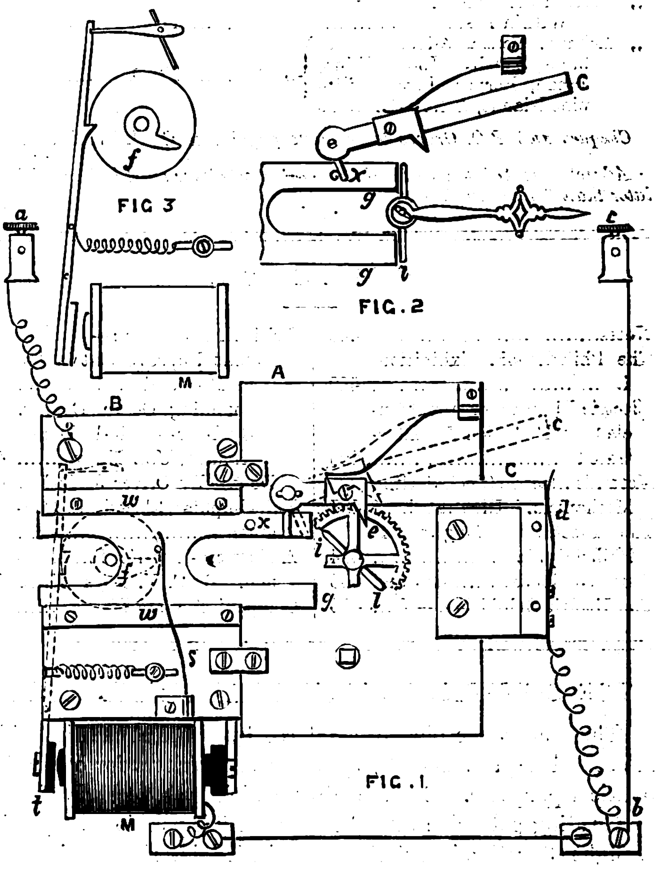
The object of this device is to set a great number of clocks synchronously with a far less amount of battery-power than is possible by the apparatus in use up to the present time. Clocks in which electricity is the motive agent are subjected to so many disturbances that it seems to be the common opinion that some device for setting the clocks periodically must be substituted. A broken wire or a short circuit, and we have no time. Expense is a great consideration, and few persons can afford to buy new clocks or to pay the price demanded by the companies for delivering to them the standard time.

The above-mentioned disadvantages are avoided by the Kettell mechanism, which is thoroughly effective, can be attached to the nicest parlour clock without in any way spoiling its beauty, for it is placed within the clock, and it can be furnished, moreover, very cheaply. A break in the wire does not interfere in any way with the going of the clock, and a poor clock can be made to indicate exact time by means of this device.

In Fig. 1 the device B is shown attached to the clock A, which as shown can be set from the telephone or telegraph wire, thus necessitating no extra line. This is accomplished by the lever C, which is moved by a pin attached to the wheel carrying the hour hand.

Except at the time when the clock is to be set, the lever C rests in the position shown in Fig. 1 by the full lines. The course of the current is then, binding screw *a*, lever C, spring *d*, to *b*, binding screw *c* to line. In this position telephoning or telegraphing can be carried on through the line. When, however, the clocks are to be set automatically by the pin *e* on the hour wheel, the lever C is raised to the position indicated by the dotted line, and then the current must pass through the electro-magnet M. By the central office regulator the line is broken for a few minutes before the time for setting, and the clocks being as shown in the dotted lines Fig. 1, when the regulator again makes the circuit, the current, passing through M, releases a train of wheels in B, and the cam *f* regulates the clock. This is accomplished as follows:—On the arbor of the minute hand are fastened two pins, *i i*, and when the current from the central office regulator, sent through the magnet M, releases the train of wheels in B, the cam *f* pushes forward the slide bearing the arms *g g*. These pressing against the pins *i i*, bring the minute and hour hands to their proper position. When the arms *g g* impinge the pins *i i*, the pin *x* throws the lever C forward, as shown in Fig. 2, and allows it to fall back into its proper position, so that succeeding impulses do not affect the magnet M. The spring *s* brings the slide back to its position ready for another setting. Thus all the current required is simply what is necessary to attract the armature *t* of the magnet M. Its action is as sure as a Morse instrument. Fig. 2 shows clearly the action of setting the hand, and Fig. 3 the magnet and cam wheels.

In case it is not desirable to use the telegraph or telephone wire for setting the clocks, then the only circuit needed would be through the magnet M, and the shunting device C *d*, &c., would disappear. The current would then be sent at the proper time from the central office by the regulator, automatic in its action, release the wheel work in B, and set the hands.



The works in B are simply the striking works in a clock, and in case the clock has a striking device, it can be used to do the setting.

We have seen this apparatus at work at 17, Devonshire-square, where those in charge will welcome investigation.

RATS AND UNDERGROUND CABLES.—*Iron Age* gives an amusing incident in connection with the laying of the underground cables in Washington. The receptacle for the wires had been laid for four squares and covered over very carefully, when it was discovered that no wires had been placed in the receptacle, and the whole thing had to be taken up. As a companion piece, a Washington telegraph manager tells of a similar incident which happened in London many years ago. One of the lateral wires connecting with an underground cable had been drawn out for repairs without attaching a leading line to it by which it could be drawn through again. In this case the remedy consisted in fastening a fine steel wire to a large rat and setting him at liberty in the pipe. A ferret was started in after the rat, and the latter ran the entire length of the pipe, bringing the wire with him.—*Sanitary Engineer.*

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THE ELECTRICIAN.

TO CORRESPONDENTS.

ll letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes 445
The Philadelphia Exhibition. I. 450
Electric Lighting of the Ironclad "Richelieu." Illustrated 450
Kettell's Electric Clock Setting Mechanism. Illustrated. ... 453
The Electrical Congress at Philadelphia 454
Correspondence ....455 and 456
The Health Exhibition.—X.... 456
British Association:—
Recent Improvement in Apparatus and Methods for Sounding Ocean Depths. By Rear-Admiral Daniel Ammen, U.S. Navy 457
Dust. By Oliver J. Lodge. 459
Philadelphia Electrical Congress 459
A Magneto-Electric Phenomenon. By C. V. Boys Illus. 462
Companies' Share List 464

THE ELECTRICAL CONGRESS AT PHILADELPHIA.

There are some phrases gendered by political studies which are seized with avidity by speakers and writers for other than political purposes. Such is that which was recently framed by a leading politician when he spoke of "legislation by picnic." A slight alteration into "science by picnic" describes the itinerant meetings and congresses annually held under the auspices of various scientific bodies. There is no doubt that science does largely benefit by these meetings, and they form an opportunity for mutual discussion that could not be obtained in any other way. Few men would care about travelling a more or less great distance—putting up with the inconvenience of crowded hotels, and so on—were there not a corresponding amount of pleasure, and we may be sure that this pleasure is not altogether obtained in the meeting room. It is found in the meeting of old friends and making new ones. The meeting this year of the British Association at Montreal enabled many of our most able scientific men to visit the American Association and the Congress of Electricians at Philadelphia. Our correspondent at Philadelphia has commenced a report of the Exhibition now being held in that city, and has pointed out that the report of the Congress given in the *Public Ledger* is a fair abstract of the proceedings. Pending the arrival of a more complete report we give that, showing the many important subjects discussed at the Congress. The President advocated the formation of physical laboratories, and there is one remark of his worth all the comment it may obtain. "Let," he said, "the professors be given a liberal salary, so that men of great talent may be contented." It seems to us that the present system is altogether wrong. A college is established, and the professor is given a salary that is inferior to the wages of many a cook or valet. It is necessary, therefore, in order to live respectably, that the professor undertake extraneous work, such as that of a consulting engineer, chemist, or electrician, otherwise he may find it necessary to proceed to that most objectionable practice of frequenting the Patent Office. We strongly hold that a professor should eschew that modern attraction—that working as he does with public funds, directing as he does the minds and hands of students, it is, to say the least, scarcely honest to go with the results of such work to the Patent Office. That man is not worthy of the position of professor whose idiosyncracies are not so constituted as to make him feel the great responsibilities of his profession. It is his duty to give his pupils and the world free and exhaustive information as to his discoveries—his privilege is to write and to teach. Unfortunately nowadays the title of professor is taken by many who have no more right to it than they have to the title of duke or prince. By all means let us hasten the time advocated by Professor Rowland, let us restrict the use of the title to those who may legitimately use it, and let us pay them in such a manner that they may be content. It is a singular fact that professors at Oxford or Cambridge do not haunt the Patent Office, that the bad example has come from north of the Tweed, and that it is being followed by far too many. It is well known the professors are not overpaid in Scotland; and although the Scottish Universities can boast of a proud succession of eminent names, it must be remembered that the times are changing, so that classical and metaphysical knowledge is giving place to physical, bringing the student more and more into contact with business and the remuneration obtained in business. The opinion we have expressed is not very general; but we assume this is because professors are not well paid, and are therefore not content. It has been pointed out again and again that if the manufacturers of the country and the country at large benefit by the work of students, it is but fair that an adequate return should be given to the student. We hold very strongly to the opinion that almost if not quite all the professors of physical science are underpaid to an extent that is not generally understood. A good chemist can command a fair income; a first-class chemist—a man among men, among those from whom professors are made—can command a very high salary if he cares to enter the field of applied chemistry. The science of chemistry has done more for the industries of England than any other branch of science. There is hardly a manufacturer of iron or steel but has a special department devoted to the chemistry of the subject, and it may be employs a number of men to make analyses and researches in a certain direction. Professor Rowland certainly opened a wide field of discussion when he referred to the subject of the payment and contentment of professors. There is no class of men so badly paid as those engaged in education. The prizes of the educational profession are few, the work all important. The value of many of the "chairs" in the newer colleges is from £300 to £400 a year, and for this we ask an able man to devote his whole time to the education of the world. The salary is not that of many a foreman in a works.

There is another question we should like to refer to now, as it seems one that is being energetically pushed for solution. It is the adoption of a new unit for horse-power. Let us assume that this question is important, that its solution should

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not be delayed. Yet we think it possible to be too precipitate. The energy that electricians have to deal with is as yet comparatively small. One of the Atlantic liners develops more energy from its engines than all the electric light apparatus in the world, and it would therefore seem somewhat uncharitable if electricians attempted to force a new standard of horse-power upon engineers. We would suggest that a committee selected by the societies connected with engineering as well as the British Association be requested to report on the subject. Surely our notation and nomenclature are sufficiently mixed already without adding to the confusion. According to the Congress, the horse-power is be one thousand, instead of seven hundred and forty-six watts. Will engineers accept this? If not, we shall have one series of books and papers retaining the old standard and another series following the new standard. The subject cannot be said to have received due consideration, and therefore the acceptation by the Electrical Congress in Philadelphia may be regarded merely as tentative, the real adoption of the standard even by professed electricians awaiting further authoritative recognition. We may further point out that while the adoption of such units as the "ohm," "ampere," "volt," &c., interests electricians only, the alteration from the recognised standard of horse-power has a far wider interest. The one concerns a few score of men at the most; while the other interferes with recognised practice throughout the whole world. The two questions here referred to seem to be the most important mooted at the Congress, and we trust will receive that careful consideration they undoubtedly demand.

CORRESPONDENCE.

COMPOUNDING DYNAMO MACHINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I do not think the practical application of the numerous theories for compounding dynamo machines has been discussed in your pages. The subject is interesting from a scientific point of view, and of the utmost importance commercially, and therefore, with your permission, I will state what I have learnt on the subject, in the hope that my letter may be amplified or corrected by other correspondents.

A well-compounded dynamo running at a fixed speed will keep the E.M.F. at its terminals the same whether the circuit is completed by, say, one lamp or 100 lamps. We may infer from this that the magnetic field in which the armature rotates remains the same under all conditions, and as the E.M.F. at the terminals is constant, the current through the shunt wire is also constant. When the machine is maintaining *one* lamp only, the field must necessarily be due almost wholly to the current through the shunt wire on the field magnets, as the, say, one ampere flowing through the few turns of the series wire can make no appreciable difference; when 100 lamps are in circuit the current through the shunt will remain the same as before, but the current through the series wire will be, say, 100 amperes. In both instances the magnetic field, as a whole, remains the same, and therefore the magnetism caused in the last case by the series wire must be neutralised in some way, no doubt by the field set up by the armature. Is this consistent with high efficiency? I know it is very convenient in practice, but I should be glad if some of your correspondents would give figures to show at what cost the convenience is gained. The latest Edison machines arrived from America are simply shunt wound, and I am not aware that Edison is slow in adopting improvements.

I should also like to be informed if there is any machine actually in the market that will keep the current fairly constant when the external resistance is altered so that a variable number of arc lamps in series may be maintained without increasing or diminishing the candle-power of each lamp.—Yours, &c., L. MILLER.

London, Sept. 20.

[We insert the above letter, not that it refers to a subject that is new, for not only has the subject of "compound machines" been dealt with by Mr. Kapp in our columns, but it is referred to in recent electrical text-books, such, *e.g.*, as that of Professor S. P. Thompson. This letter, however, may show the necessity of keeping abreast of the times by the constant reading of the most recent publications.—ED. *E.*]

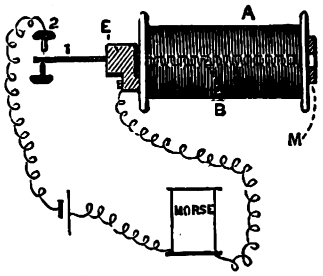
RELAYS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should feel much obliged if you or some of your readers would give me any information on the following subjects:—

The relay, as will be seen by the accompanying diagram, is composed of a bobbin of ordinary copper wire, A; but instead of having a fixed iron core it has a tiny soft iron bar, B, carrying a brass arm with platinum points, pivoted at E. Its movements are quite free within the hollow of the coil, and can be controlled by a movable magnet, M, attached to the end of the bobbin frame. On the passage of a current through the coil the soft iron bar moves, the local circuit is closed by 1 pressing against 2, and the "Morse" is acted upon.

It would seem that by means of this arrangement any change in the resistance of the line, say of a thousand ohms, more or less, does not affect the signals, and no readjustment of the relay is necessary.



What I wish to know is whether the inventor has done well in patenting this instrument, or whether it is another case of "nothing new," &c.

I have a very vague idea of some such arrangement being once used by the late Mr. Varley, but my memory cannot help me further.

My second question relates to the working speed of various instruments. In Hospitalier's *Formulaire Pratique de l'Electricien* for 1884, page 268, it is stated that the "Wheatstone" can only transmit 90 twenty-word messages an hour, whereas the "Baudot," with six keys, can transmit 240 twenty-word messages an hour, the "Hughes" 60, the "Recorder" 25, and so on.

Now, I have always understood that the "Automatic Wheatstone" was capable of much better work than this, and I should like to know if the speed as above given is the result of French or English experiments.

Apologising for trespassing on your space.—Yours, &c.,
20th September, 1884. X.

PROFESSOR FORBES'S REPORT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: *Re* your leader and Professor Forbes's report on the electric light at the Health Exhibition, I went on Monday last to try to find the two curiosities therein mentioned, viz., "Fülcher" dynamos, and the 1,000 lighter Ferranti, fed by a "large quantity of Siemens's direct current dynamos." I failed to find either.

Professor Forbes also says that the only secondary batteries in regular action are those of the Consolidated Company, but I found some Elwell-Parker cells lighting some furnished rooms

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in the South Gallery, and the man in charge assured me they had been in regular action since the opening.—Yours, &c.,

September 24th, 1884. OBSERVER.

TREES AND LIGHTNING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of Sept. 6th, on page 397, you republish a very interesting letter, written by Mr. F. G. Heath, with regard to the dangers of lightning. Mr. Heath stated he was surprised to read that a remarkable suggestion had been made, viz., that metal rods should be fastened to the trunks of trees at their bases, to divert the lightning from the killing of human beings who might be taking shelter under them, *for it is well known that the fluids of an animal body are much better conductors of the electric fluid than any of the metals.*" [The italics are mine.]

Question 1. As leading electricians have invariably stated that the metals are the most perfect conductors, and Professor Silvanus Thompson places *the body* in the list of *partial* conductors, it would be rather unfortunate if this apparent contradiction was not cleared up. Is this correct?

Then the writer proceeds to give "a very striking illustration of this fact in the death of Mr. Crosse, who had a gigantic electrical apparatus *and an enormous Leyden jar* [the italics are mine] set up in his house, and he was wont to tap the clouds by means of long conductors. During a terrific thunderstorm he became so deeply absorbed in the great sparks which were going "click," click," into the metal knob of his jar, that he approached a little too close to it, and was killed."

Question 2. In this striking illustration of the supposed better conductivity of the human body than the metals, the writer does not consider the fact that "an enormous Leyden jar" was a kind of storage battery, and that the pent up energy had no means of escape—*no metal conductor to carry it silently to the ground*—but a human body in proximity. Is this correct?—Yours, &c., S. E. K.

AN ELECTRIC LAUNCH.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice in your issue of the 19th a letter referring to an electric launch which I recently tried on the Bolton canal. With reference to a great number of reports which appeared in the various papers of this trial, most of them were grossly inaccurate; for this I am not responsible. Some of them contained statements as to speed, &c., which every one who has had to do with launches knows were simply impossible for a boat that size. But, with regard to the maximum speed obtained, if your correspondent had been on the banks of the canal and had made good use of his understandings he would have been fully convinced. I may say that after the report appeared I found an error in my calculations, but it was so slight that it was not considered worth while to trouble you with the correction.—Yours, &c., W. BANKS.

Bolton, 23rd Sept., 1884.

NON-MAGNETISABLE WATCHES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Volk gives a good idea in his letter of last week as to a method of making a non-magnetisable watch. I met an officer of the American war ship "Shenandoah" in South America a year or two ago, who had a watch in which all steel was omitted, the spring, screws, &c., being made of a species of phosphor bronze throughout, and he assured me it kept good time. I tested its non-magnetisable properties with great success. If such could be produced in England at a reasonable rate, I am sure they would be eagerly bought.—Yours, &c., A. GRUNDY.

Law Courts, September 24th, 1884.

HEALTH EXHIBITION.—X.

THE ELECTRICALLY ILLUMINATED FOUNTAINS.

The number of visitors to the "Healtheries" has already exceeded the total number that attended the "Fisheries;" so there is every reason to believe that, by the close of the present Exhibition, it will have been visited by a number of persons equal to the population of Greater London, of Holland, or of Belgium. Even the most ardent hygienist or social reformer can hardly suppose that all these masses are attracted by a desire to study the laws of health; what to eat, drink, and avoid; or how best to secure the well-being of themselves and their fellow men. A certain percentage of such there is no doubt, but the great majority has not yet attained so high a standard. No, the attraction has been a magnetic, or, rather, an electrical one. The people of London have now got a place, brilliantly lighted, where, after business hours, they can instruct themselves and get new ideas, perhaps; but, at any rate, have the senses of seeing and hearing, to say nothing of tasting, gratified in a rational manner, and see many a thing of beauty which shall be a joy for ever.

There can be little doubt that one of the principal, if not indeed the principal, attraction of the present show is the perfectly unique display of fountains, in conjunction with the electric light, devised by that potent water sprite, Colonel Sir Francis Bolton, and carried out and worked under his personal superintendence. Through his kindness we have had an opportunity of a "peep behind the scenes," and of seeing how the whole thing is done.

We were first put in charge of Fred. Phillips, the colonel's coxswain or right-hand man, who, from the specially constructed house or kiosque near the lake, had us rowed over to the island in a little dinghy made of Willesden waterproof cloth. Access to the chamber, 22ft. square and 4ft. 6in. high, which is half under water, is gained by clambering through a narrow horizontal opening scarcely more than a foot high. To those who have been admitted to the hidden mysteries known as "behind" in a theatre, this chamber at once recalls the mazarine, or more properly mezzonine floor, where are worked the traps that launch the beautiful faries into, it may be, "the glittering realms of refulgent light." Here is an apparently inextricable confusion of pipes and electric leads, the latter communicating with five hand-worked lamps arranged in parallel, the carbons of which last half an hour with setting up. The carbons form a slight angle with the horizon, the positive carbon being at the bottom instead of at the top, as usual, so as to get the crater to shine upwards.

Each lamp is of 5,000 candle-power, so as to make sure of carrying all the current generated. This is supplied by a Siemens B2 dynamo, compound shunt wound, giving 420 amperes at 84 volts, placed in the electric lighting annexe, while the current that goes through the lamps is 60 amperes. It is led by a double cable of nineteen No. 12 copper strands, insulated with gutta percha and cross-webbed braiding, which is further protected by a lead pipe for the portion laid in the water between the shore and the lake. In the island, the cable branches off into six cables of nineteen No. 14 strands. Above the lamps are holophotes, such as are used in lighthouses, for directing the rays upwards, and concentrating them on the water jets. Above the holophotes are frames with variously coloured glasses sliding in them, for producing those beautiful "effects" which are so much admired; and above all are plates of stout plain glass, for excluding the water as it falls down with a splash. Three incandescent lamps in the kiosque (not chamber on the island) are worked off the same circuit. The lamps are managed by Mr. Urquhart, Sir Francis Bolton's principal assistant for the electrical portion. The wires were laid under the direction of Mr. G. Schülz, assistant engineer of the electrical department, of course under the general superintendence of Mr. W. D. Gooch, engineer in charge.

In the chamber on the island is a sixth lamp for dissolving-view apparatus, which throws pictures on a water screen, at the back of the basin in front of the Prince Consort monument. The water rises from a slightly curved pipe, through small transverse slots sawn in its upper surface, alternately on

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either side of the centre line. The dissolving-view apparatus is, however, but little used now, as the varied effects produced by the fountains, combined with the electric light, are sufficient to last out the half hour to which the display is limited.

This lamp and six of 1,500 candle-power for lighting up the cascades from the water columns, now seldom used, with aluminium shields at the back for reflecting the light, are all supplied with current from the same dynamo as the five 5,000-candle lamps in the chamber.

The water for the fountains is laid on by the West Middlesex Company, through one 12in. and three 8in. Tyler meters, with a pressure due to a maximum head of 160ft. and average of 150ft. The pipes were laid by Messrs. Simpson and Co., of the Grosvenor-road Engine Works, and the ornamental flower jets supplied and fixed by Baskerville and Co. There are five principal cocks and 22 valves, besides the centre one for causing the jets to jump. There are three rings of jets in the basin, surrounding the central jet, which attains a height of about 120ft., and the four jets round it about 60ft.

But an electric call resounds through the chamber from a telegraph apparatus, made by Archbutt, the current of which, supplied by a powerful Lane battery, is sent through two wires (one for return), from the clock tower. This announces that Sir Francis is in the tower, and that in five minutes the show will begin. Then come, in succession, the signals "Stand by," "On centre lamp," "On four side lamps," "On centre jet," then "On side jets," then, it may be, "On centre ring," or "On the four convolvulus," and then, perhaps "Jump centre jet" or "Jump side jets." These words of command are also varied by orders to put on the differently coloured glasses over the lamps, in constantly varying combinations. There is a regular programme of changes; but it is rarely adhered to, as the water sprite is constantly devising new effects and combinations, each one more beautiful than the last. Besides, the not knowing what signal may come next has the effect of keeping the men up to the mark; and it is surprising with what rapidity each command is carried out.

With five or six electric lamps, and six men working, in a perfectly closed chamber of the dimensions given above, to say nothing of interlopers like ourselves, it may be supposed that the temperature and the atmosphere soon became unbearable. In the early days of the illuminated fountains the thermometer stood at 110 Fahr., and sometimes attained 120. But Mr. F. H. Smith has put in three of his automatic syphon ventilators, of 6in. internal diameter, each of which reduces the temperature by 10 degrees. On the night of our visit the external temperature was 78 degrees, that of the chamber before commencing the display 70 degrees, and at the end 80 degrees. The action of the ventilator depends on the effect of a current of warm vitiated air, ascending, simultaneously inducing a current of cold air to flow in to take the place of that which has been displaced.

During the second display we mount the clock tower, whence is obtained the best view possible of the fountains. Here is Sir Francis, *en costume de guerre*, who gives the order, "Umbrella up sharp at the half hour." The "umbrella" is the covering of red tammy that is hoisted up to dim the brilliancy of Edmunds' mast light, so that it may not interfere with the light specially thrown on the fountains. The display begins; and the Colonel, looking out through a peep hole, with his telegraph before him, watches the effect produced by the various combinations of jets and coloured lights. No sooner, apparently, does he give the signal, than the change is made. But other effects are worked directly from the clock tower. Here are two stationary lamps of 2,000 candle-power, with lenses for directing rays on to the fountains; and above, a Siemens projector of the fifth order, of 6in. focus, for following up the jets when they are "jumping." There are also two other lamps in "crows' nests," one on either side of the clock tower, and at some distance off, for throwing rays diagonally, but these are now rarely used.

The two fixed lamps in the clock tower are in the general Brush circuit, which maintains 24 lamps about the buildings and grounds; and the current for the projector and the two lamps in the crows' nests is supplied through a separate circuit from a Bürgin dynamo made by Crompton.

This display of electrically illuminated fountains was at first given only on Wednesday and Saturday evenings; then Monday was added. Now they are shown on every evening except Tuesday, and such is their popularity that they will henceforth be shown every night until the close of the Exhibition. On the occasion of the hospital *fête* the display lasted three hours and a quarter. Notwithstanding this immense "run," there has not been a single hitch in working; and not a joint in the pipes has yielded, although the pressure is so great. Certainly the fountains at the Crystal Palace, at Versailles, Saint-Cloud, Baden Baden, and Wiesbaden are larger, more elaborate, and more magnificent than those at the Health Exhibition; but they have not that special charm due to the peculiar method of illumination devised by Sir Francis Bolton. Then, again, we know that there was a fountain at the old Panopticon in Leicester-square, on the site of the present Alhambra, that was illuminated by the lime light reflected from above; and fountains have been illuminated by rays from the lime or electric light projected upon them through coloured glasses for many years past, but never before have such beautiful and varied effects been produced; and the question arises, What greater attraction can be devised for the succeeding exhibitions, viz., the "Inventories" next year, and the "Colonies" in 1886?

THE BRITISH ASSOCIATION MEETING AT MONTREAL.

The following abstract of a paper on deep sea sounding will be interesting to all engaged in cable work, and they will be able to corroborate the testimony as to the efficiency of Sir W. Thomson's apparatus and its modifications. The paper is entitled

Recent Improvement in Apparatus and Methods for Sounding Ocean Depths.

BY REAR-ADMIRAL DANIEL AMMEN, U.S. NAVY.

The intended laying of the Atlantic telegraph cable some thirty years ago, awakened a general as well as a specific interest in relation to the depths of the sea and in gaining a knowledge of them. Fair results were then obtained by Lieutenant Berryman and others, considering the imperfect appliances known at that time, to sound the relatively small depths of the North Atlantic. Shortly after, the simple and effective device of Lieutenant Brooke, U.S.N., for detaching the sinker, was in use; and also the cup of the late Rear-Admiral B. F. Sands, for securing specimens of the bottom. Able and thoughtful men were these pioneers in sounding the depths of the sea, and substantial results came from their labours, but owing to imperfections of one part or another of the means employed, the operation of sounding was painfully slow, only approximately correct, and at times grave doubts existed as to some of the actual depths obtained.

In the autumn of 1871 scientists and the public were informed of the success of Sir William Thomson in sounding in a depth of 2,700 fathoms in the Bay of Biscay. He used pianoforte wire, Birmingham gauge 22, weighing 14½lb. to the nautical mile, capable of bearing a strain of 230lb. His dynamometer, had three miles in length of this wire been wound upon the drum, would have been still so portable that one man could have carried it with ease. What was accomplished by it excited the hopes of hydrographers, which time has wrought into the most gratifying and undeniable realisation.

Early in 1873 the Navy Department was preparing to make extended soundings in the Pacific Ocean. The Chief of Bureau of Navigation, charged with the execution of this work, asked the advice and assistance of Sir Wm. Thomson. He was good enough to order wire and such apparatus as his personal experience suggested, and to send carefully prepared instruc-

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tions for effecting the object in view; in short, he did everything within his power to make the use of his apparatus successful. The substitution of it and its effective manipulation by Captain Belknap, United States Navy, marked an era of progress in deep sounding and in possibilities of obtaining true ocean depths as truly as did the steamship mark an advance in traversing wide and stormy seas with celerity and certainty. At that time Belknap commanded the "Tuscarora," and until the sounding apparatus was sent, had only the fitments that belong to vessels of war. Notwithstanding these disadvantages, the results obtained were eminently satisfactory. For specific information the scientist is referred to No. 54 of the Hydrographic Office publications, entitled "Deep-Sea Soundings in the North Pacific Ocean," 1874.

In a letter to the Chief of Bureau of Navigation in July, 1874, difficulties were stated in the use of the apparatus that happily had been overcome by Belknap. Sir William wrote: "I have therefore resolved to alter the apparatus considerably, and am preparing for trials on a new plan which I hope to carry out in the five or six days we shall remain here, and, if possible, shall write you reporting the result." In reply to this note, he was informed with as little delay as possible in relation to the several modifications made by Belknap, which enabled him to get soundings in the most satisfactory manner in depths of more than 4,000 fathoms. Sir William expressed by letter, and publicly, his gratification at the admirable results obtained by Belknap, and his thanks for the specific information sent him relating to the modifications of apparatus that had been made.

In depths of 2,500 fathoms, Belknap found it necessary to make several additional revolutions of the drum by hand, on the sinker striking the bottom, to prevent jerks and strains on the wire which otherwise would have occurred from the rolling of the ship. This necessity was due to the almost instantaneous ceasing of the drum to revolve on the sinker touching the bottom. He reported his soundings at this depth as probably more accurate than many casts in depths of 100 fathoms with an ordinary lead and line. He added: "I expect to accomplish all the work with it (Sir William Thomson's apparatus) which the department has assigned me, and, if I succeed, no greater compliment could be paid to the genius of the inventor."

The winding up of miles of wire on a light drum gave a cumulative pressure on the original apparatus in deep soundings such as to make a continuous system of repair necessary, and finally the substitution of steel drums in the naval service.

To fully appreciate the advance made through the use of this apparatus, it is necessary to bear in mind the tons of rope required to reach depths of four or five miles, and its rapid deterioration from use, the cumbrous apparatus, the slowness of the process even under the most favourable conditions, and what is of greater import, the uncertainty as to the actual depth sounded, arising in part from the under currents of the ocean carrying great bights of rope in one or more directions, and in part from the very small proportion the weight of the sinker must bear to the hemp line, but in a more marked degree from the "stretch" of the rope under tension, and the gradual shortening of it as soon as the sinker reached the bottom.

The report of the Secretary of the Navy for 1874, p. 61, discusses the advantages gained by the use of wire as follows:—The small amount of weight and space required for the apparatus; the large weight of the sinker relatively with the weight of the wire necessary even in sounding the greatest depths, and the very little surface friction of wire in its descent. Miles of wire have very little "stretch" at ordinary tension, and hemp line a great deal, from which, in the first case, the indications of the dynanometer would be almost instantaneous, and in the second would be obscure and quite uncertain as to the exact depth and moment when the sinker reached the bottom. Other advantages are the ease with which the wire is preserved from deterioration. It is stated further, "The problem of measuring the exact depths of the ocean and bringing up parts of the soil from their beds may now be regarded as solved."

The deepest sounding known was taken by Belknap off the east coast of Japan, 4,655 fathoms, a little more than 5¼ statute miles in depth. He took 304 soundings of 1,000 fathoms or upwards, mean time of descent for the first 1,000 fathoms, 10min. 6sec.; 161 of 2,000 fathoms or upwards, time of descent in the second thousand, 11min. 36sec.; 38 of 3,000 or upwards, time of descent for the third thousand, 12min. 40sec.; 9 of 4,000 fathoms or upwards, time of descent for the fourth thousand, 15min. 54sec. The rate of reeling in by hand was much slower than now attained by the use of steam power, yet it was surprisingly rapid and easy in execution in comparison with the reeling in of hemp line.

In the great depths off the east coast of Japan, with the strong currents, Belknap's appliances were in fact taxed beyond a perfectly satisfactory execution, the wire having parted on one occasion at a depth of 4,643 fathoms, before reaching the bottom, and again in reeling in, after sounding in a depth of 5¼ statute miles. Larger wire and heavier apparatus can develop beyond a doubt the depths called by the Germans the "Tuscarora Deep." As now supposed from the soundings taken, this deep water lies at a mean distance of 120 miles from and parallel to a line drawn from the most northerly Cape of Niphon and the most northerly Kurile Island. This is a general direction of N.E. ½ N. It appears to be at least 250 miles in length, and is probably much longer. Captain Belknap justly says that these extraordinary depths contiguous to a region of elevations afford a field of operations of great interest to the hydrographer.

The soundings made by Belknap comprise an arc of a great circle between the northern part of the Island of Niphon, the Aleutian Islands, and Puget Sound; another line between San Diego, Calvia, the Sandwich Islands, and the Bay of Yokohama; and a development of the true ocean bed from Puget Sound to San Diego. They reveal a dozen or more submerged elevations, veritable mountains "full many a fathom deep."

In fact, these soundings furnish the first extended and undeniable development of extraordinary and abrupt inequalities in the depths of the sea far away from the land. We owe this to the inventive genius of Sir William Thomson, and to the professional capacity of Captain Belknap, who not only knew how to make the best use of what he was furnished with, but also had the capacity to cure defects in the apparatus, such as they were. In depths of 3,000 fathoms he used a detachable sinker of 55lb. In greater depths he supplemented this with 20lb. to 30lb. of lead. In order to secure specimens of the bottom in larger quantity, Belknap designed several cups, one of which is now unsurpassed for efficiency by whatever modification or other design, as it did its work perfectly.

Although at the time these soundings with wire were determined on the superintendent of the Coast Survey of the United States hardly hoped a favourable result from the use of wire, as it had not been adopted by the "Challenger," which had been fitted out for scientific investigation some months before, so able a scientist was not slow to adopt what Belknap had shown was so admirable. In Sigsbee's "Deep-sea Sounding and Dredging," published by the Coast Survey, Washington, 1880, we find, chapter 1:—"In August, 1874, the 'Blake,' Commander John A. Howell, U.S.N., was provided with one of Sir William Thomson's sounding machines for wire." Commander Sigsbee in the following months made modifications in the apparatus, giving additional facility and rapidity of execution in sounding, but nothing could be added to the accuracy of the results that had already been obtained by Sir William and Belknap.

In the soundings of the Coast Survey, executed by Sigsbee, Bartlett, Tanner and others, we have a veritable revelation in the contours and depths of our coasts. They have brought to our knowledge the wonderful cleft in the crust of the earth on the line of the Hudson River extended 100 miles beyond Sandy Hook. Scarcely less interesting, but not so startling, are the plaster casts of the Gulf of Mexico, and of the Carribean Sea. It is a grateful duty to indicate to whom honour is due that the depths of seas are no longer an unrevealed and unfathomable mystery; that much is now known, and that

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ocean depths in all navigable seas will ere long be placed on maps with far more accuracy than are the heights of mountains above the level of the sea.

Dust.

In his evening lecture before the British Association, Professor Lodge performed a number of experiments, electrical and otherwise. The following is a short description of these experiments:—The first experiment was one of Aitken's, in a tube described by Tyndall as optically empty. This tube had been exhausted of ordinary air, and then air had been allowed to filter quickly into it, passing through tightly-packed cotton wool, which was moistened with glycerine, then through dry cotton wool, and lastly through water. This tube was placed opposite a lantern containing an electric light, and on the room being put into partial darkness, and the beam of light being turned on to the tube so as to pass through it, although the light was seen beyond the tube, the tube itself was in comparative darkness, as the dust-free air would not exhibit the light. Clouds are formed of condensed vapour of water with dust, and not simply of vapour. He fully explained the formation of clouds and of vapour, after which he named the methods of removing dust from the air, as follows: (1) Filtering through tightly-packed cotton wool; (2) allowing it to settle; (3) condensing vapour in it several times; (4) calcining it; (5) electrifying it.

The second experiment was to explain this—that when fine particles of dust were introduced into the same tube and condensation being then caused to take place, the necessary dust particles or nuclei were introduced by the heating of a fine piece of platinum wire, which did not show any diminution in the finest scales; and yet it must do so, as plenty of dust was present. After the wire had been heated, the condenser was then applied, when the tube at once appeared full of mist, as there were plenty of nuclei for the globule to form round.

The next experiment the lecturer said was a childish one to illustrate the action of nuclei in condensation, and better understood by children than grown-up people; it was simply writing on glass which was made visible by breathing on the glass. This was due to the fact that on the surface of the glass were particles of dust; these were partially cleared by the scraping of the pencil or finger, consequently the condensed vapour settled unevenly. This was shown by placing a piece of glass so that it was shown on the lantern screen, and on the lecturer writing and then breathing on it it was very apparent, even the globules being apparent.

Turning to fog, such as was seen about the Straits of Belleisle, which made icebergs so dangerous, the electric light was powerless to penetrate it. But if the electricity were discharged from the masthead on a small scale it would coagulate it into globules, which would fall as rain, the effect being somewhat similar to that of oil on water.

The fourth experiment, to show that heat dissipates the small particles, a beam of light was turned on from the electric lantern through a magnifying glass; the dust was easily seen, but on a Bunsen burner being placed underneath, the dust disappeared, and a black space appeared. That this was not smoke was proved by a turpentine lamp being placed underneath, when the smoke appeared to be white instead of black.

The lecturer referred to a diagram showing the circle of clear air round an electric wire, which the dust-particles seemed to avoid.

Taking a bell glass, Professor Lodge placed under it two lamps, and said that supposing one to be a vessel of hot water and the other of ice, if the bell jar was filled with smoke, after an interval of time the smoke would be found deposited on the cold vessel but driven off the warm one.

If a piece of crystal were suspended in a vessel full of smoke, and then a beam of light were directed upon it and it became electrified, the smoke would solidify in a brush-like form all round this crystal, exactly as iron filings did round a magnet. To illustrate this, a bar of iron was magnetised and iron nails at once became attached to each other and to each end, and it was exactly the same way in the case of smoke round an electrified crystal.

One way of dissipating fog was illustrated, but Professor Lodge explained that he had brought two large, specially made globes, and having got them successfully through the Custom House at Quebec they were brought up to Montreal. On unpacking, however, one was found to be broken. The other was carefully put into its position and the experiment tried. Everything went on right, but as they turned to leave it, the globe broke to pieces; consequently the experiment had to be tried with a less satisfactory globe, and was probably hardly so successful. The globe in question was placed on a framework, with the open mouth downwards; projecting into it was a pointed wire connected with a plate electrical machine. Magnesium wire was burnt in the globe until it was filled with a dense white smoke. The current of electricity was then turned on, when the smoke was seen to be settling in streamers on the points of the wire, then to be crystallising or solidifying into filaments all through the globe and settling in a similar way on the sides. In conclusion, to alter the familiar adage, the best advice to young investigators proved to be: "Stick to pure science, and applications will take care of themselves." And those who devoted themselves to scientific pursuits would find themselves amply repaid for their labour and trouble.

PHILADELPHIA ELECTRICAL CONGRESS.

On the first day of the meeting of this Congress nearly all the seats in the hall were occupied, many of the members of the British and American Associations for the Advancement of Science being present. The meeting was called to order by Professor Simon Newcomb, who, in briefly announcing the objects of the Conference, remarked that it was only in consequence of the reduction of electricity to mathematical laws that it had become possible to make it of such great practical use.

The President of the Conference, Professor H. A. Rowland, of Johns Hopkins University, read an elaborate review of the progress made in electrical science, especially during the last three hundred years. He said it was only after the invention of the Leyden jar that the idea of forming a current of electricity occurred to man. Two hundred and twenty years of study were necessary before the telegraph was possible. "We are still but children, studying the A, B, C of electricity," he said. "Electricity cannot exist without matter. When we know what matter is we will know what electricity is and what magnetism is." He favoured the adoption of international standards for the measurement of electricity.

"To-day," he continued, "our country, by its liberal patent laws, encourages applied science. We point to our inventions with pride, and our machinery in many of the arts is not surpassed. But in the cultivation of the pure sciences we are but children in the eyes of the world. Our country has now attained wealth, and this wealth should partly go in this direction. We have attained an honourable position in applied science, and now let us give back to the world what we have received in the shape of pure science. Thus shall we no longer be dependent, but shall earn our own science as well as inventions.

"Let physical laboratories arise; let men of genius be placed at their head, and, best of all, let them be encouraged to pursue their work by the sympathy of those around them. Let the professors be given a liberal salary, so that men of talent may be contented. Let technical schools also be founded, and let them train men to carry forward the great work of applied science. Let them not be machines to grind out graduates by the thousand, irrespective of quality, but let each one be trained in theoretical science, leaving most of his practical science to be learned afterward, avoiding, however, over-training. Life is too short for one man to know everything; but it is not too short to know more than is taught in

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most of our technical schools. It is not telegraph operators, but electrical engineers that the future demands."

Sir William Thomson, Vice-President of the Conference, made an address, in which he said that one of the most important subjects to be taken up by the Conference was the foundation of a system of electrical measurements.

"We want instruments," he said, "that will be as quick and convenient as fish or sugar scales." He spoke of the self-sacrificing spirit of such scientists as Faraday and Henry, who devoted their time to scientific study, letting others profit by the application of their discoveries to practical use. The two-fold purpose of this Conference, he said, was to promote the application of electrical science to the wants of man, and to enable the investigators assembled to get the benefit of one another's observations and experience.

President Rowland announced that the afternoon's programme would begin with the discussion of "The Work of the United States Signal Office in Relation to Electrical Observations." Professor Cleveland Abbe and Lieutenant James Allen, both of the Signal service, opened the discussion. The subject of "The Necessity for a National Bureau of Standards, Including all Electrical Standards," was opened by Professor M. B. Snyder, of this city. The other topics were "The Adoption of an International System of Electrical Units" and "The Theory of Dynamo-electric Machines."

The second day's session of the Conference was held in the Annexe of the Exhibition. The meeting was called to order by the President, Professor Rowland, who introduced Professor Cleveland Abbe, of the United States Signal Service, who delivered an interesting address on the "Work of the United States Signal Service in Relation to Earth Currents and Atmospheric Electricity." He referred to the almost total neglect of the subject previous to the years 1880 and 1881. In those years it became necessary, he said, to train a special set of observers, who were to accompany the Greely expedition and make observations on the electrical and magnetic phenomena of the far North. Professors Trowbridge and Rowland, who were selected for this work, had afterwards continued their instructions to other chosen members of the Signal Service Corps. It was hoped to gradually extend the number of stations where electrical phenomena might be properly observed when the meeting of the International Conference of Electricians was held in Paris. At this conference the co-operation of the various Governments in this very line of work was asked, and the resolutions transmitted to our State Department at Washington, and by them to the War Department, had come to the Signal Service as orders, and hence a series of questions had been prepared and transmitted to practical electrical engineers all over the country in order that the extent of private co-operation with the Government efforts might be known. Professor Abbe had also been instructed to draw the attention of this Conference to the questions. He moved that a committee be appointed to consider the questions, and with instructions to report to the United States Electrical Commission in three months' time.

After some discussion the motion was adopted.

The President then introduced Professor John Trowbridge, of Harvard College, who opened the discussion on the adoption of the International Electric Standards. He read a letter from the Department of State to the Electrical Commission, enclosing the resolutions passed by the International Conference at Paris, asking the various Governments to legalise the measures of force as a standard in their several domains.

These resolutions fix the legal ohm as the resistance offered by a column of mercury of a cross section of one square millimetre and a length of one hundred and six centimetres at the temperature of melting water. The ampere is represented by one divided by ten in the C.G.S. system. The volt is the electromotive force which sustains the current of one ampere in a conductor whose resistance is equal to one ohm.

The next resolution was in reference to the gathering of statistics in relation to atmospheric and terrestrial electrical disturbance.

The final resolution fixes the unit of each simple light as the quantity of light of the same character emitted from a surface of one square centimetre of melting platinum at the temperature of solidification.

Professor Trowbridge submitted these resolutions to the Conference, suggesting that they be considered separately.

Professor Sir William Thomson, as one of the Paris conferees, explained how the length of the standard ohm came to be established at 106 centimetres. He stated that it was his impression that a majority of the conferees believed that the actual length of the conductor should be more accurately 106·2 centimetres, but that as there was quite a difference of opinion, amounting to three or four millimetres, it was the opinion of the Conference that the measure should be fixed at 106, as the nearest whole number, and that when observations should be more extended, and the value of the ohm definitely fixed, the length could then be altered. In the meantime, he urged the adoption of the number 106 as the means of unifying scientific work. He asked Professor Rowland to give the Conference the results of his experimentation, which he had been conducting to determine the true length of the ohm.

Professor Rowland referred the Conference to his colleague, Professor A. L. Kimball, of Baltimore, who gave these results as far as they had gone, as follows:—One British Association ohm was equal to ·9864 of the accurate ohm, and this figure must be within one three-thousandth of accuracy. The specific resistance of mercury was ·9539 in British Association units, and hence the accurate ohm should be a column of mercury of one square millimetre in section and 106·278 centimetres in length.

The motion that the Commission be directed to take the proper steps to legalise the ohm adopted at the Paris conference in the United States was adopted. Similar motions with respect to the resolution regarding the volt and the ampere were also adopted.

The resolutions concerning the collection of statistics with regard to atmospheric electricity were, on motion, referred to the same committee to which the former resolution on the same subject was referred, with instructions to render a preliminary report to the Conference, and a final report to the Electrical Commission.

The resolution with respect to making a new standard unit of light was then considered. Professor Trowbridge explained Siemens's method of studying this unit, and moved that its consideration be referred to a committee, with directions to report to the Electrical Commission. A conferee, who was also one of the examiners of the exhibition, proposed an amendment that the committee be directed to render a preliminary report to the Conference. The resolution and amendment were adopted.

Mr. W. H. Preece, of London, introduced a resolution to appoint a committee to consider the advisability of the substitution of the watt as a measure of dynamic force in the place of the foot-pound or the horse-power. He stated that the watt, since its introduction by the late Professor Siemens, had practically been adopted, but lacked any official confirmation. At the Paris Conference the proposal was negatived, on account of the German opposition to adding more technical terms, and to the fact that there was no "w" in the French language. There are 746 Watts in the present horse-power. It would cause but slight confusion to increase the nominal horse-power so that one horse-power would represent 1,000 Watts. The resolution was agreed to, and this committee was also directed to render a preliminary report to the Conference.

Professor A. Graham Bell, of Washington, called attention to the very bad acoustic properties of the hall. He moved that the chairman be directed to procure better accommodation for the Conference.

Mr. William P. Tatham, president of the Franklin Institute, offered the use of their hall to the Conference.

On motion the Conference accepted the invitation, and on motion of Professor Trowbridge the Conference adjourned. President Rowland announced the order of discussion as follows:—"The Establishment of a National Bureau of Physical Standards," opened by Professor M. B. Snyder; "The Theory of the Dynamo-Electric Machine," discus-

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sion opened by Professor H. A. Rowland; and "The Electrical Transmission of Energy." He desired it to be understood that the meetings of the Conference are freely open to the public, and that they would hereafter be held in the hall of the Franklin Institute.

The Conference assembled in due course in the lecture room of the Franklin Institute. The Conference was called to order by Professor Rowland. The President announced the committees directed during the previous day's proceedings as follows:—

On the question of the adoption of the unit of light and on the adoption of the watt as a unit of power—Professor Trowbridge, chairman; Messrs. Preece, Cross, Edison, Pickering, Barker, and Heap. On the means of gathering statistics of atmospheric and terrestrial electrical disturbances—Professor Abbe, chairman; Messrs. Allen, Trowbridge, Yates, Preece, Gisborn, and Nipher.

Professor M. B. Snyder, of the Philadelphia Central High School then opened the discussion on the "Establishment of a National Bureau of Physical Standards." After some considerations of the necessity of the legal fixation of standards of a physical measurement, and some reference to the Government work done by the Bureau of Weights and Measures and of the Coast Survey, he stated the requirements for a successful supervision of this important work. He said that the work must of necessity be a Government work to give it sufficient means to determine the scientific questions, and to give force and authority to their determinations.

It would be necessary for the department to provide first for the very best and most scientifically accurate work, and second for furnishing the public with the practical results of that work. He did not think it should be connected with any of the present Departments of the Government, lest its work should be hampered in other directions. It should include both a laboratory and observatory as well as be a centre for the deposition of standard weights, measures, and means of determining every form of power.

Professor W. A. Rogers, of Cambridge, said that there was undoubtedly a need for such an institution as Professor Snyder had suggested, but that it was a debatable question whether the ends would be reached best by founding a new department, enlarging the old bureaus, or depending upon private munificence independent of Government control. He thought that the majority of the conference would agree with him that, in order to gain proper authority, it was necessary that the institution should be under Government control. Its functions, he thought, should be more limited than Professor Snyder had indicated, and should be restricted to the determination and control of units of power only, leaving the questions of dividing or multiplying and of making new standards to private enterprise and investigation.

Professor Hilgard, of the Coast and Geodetic Survey of the United States, did not agree with Professor Snyder as to the advisability of forming an entirely new department. He thought such an institution would paralyse individual enterprise, and be productive of no good result. He was of opinion that the great function of government was to maintain equity and not to define the microscopic divisions of modern science. The United States was already a subscribing nation to the International Bureau of Weights and Measures, and this, he believed, was as far as the Government should at present be asked to go. He mentioned incidentally that he had received intelligence the day before that Great Britain, after long holding out, had also joined the International Bureau. He also referred to the work of the Coast Survey, and stated that they had several times measured base lines of ten miles and over with a smaller error than one one-millionth.

Lieutenant Allen, of the Signal Service, presented some of the work of the Signal Service Bureau of the War Department, in the way of accurate measurement of heat and the pressure of the air. He presented no opinion as to the advisability of a new department of the Government, but merely some of the scientific work done in his own department. He believed that fixed standards, especially of electrical units, was a great desideratum.

Professor Simon Newcomb thoroughly believed in the necessity for the formation of such a department. He pointed out the authoritative character of the Government stamp, and believed that an action had been taken during the closing hours of the last Congress looking to the consolidation of several of the scientific bureaus, that the present was a most favourable time to urge the formation of the department.

Sir William Thomson believed that the United States would find it absolutely necessary to have a bureau of standards much more extensive than that which it now possessed. He called attention to the good work done in England in thermometric observations by the Kew Commission. He was sure that both Governments would soon be compelled to found complete bureaus, and he was anxious that the United States bureau might be founded, and that its good work might serve as another argument for the foundation of a British bureau. Instead of restricting Professor Snyder's idea, he would rather expand it, and establish in every large city an official inspector of weights and measures. He thought that the success of incandescent lighting was now assured; that it was certain before long to become the ordinary house-to-house system, and that hence the determination of the legal volt-ampere would be as important as that of the metre or the yard.

Mr. W. H. Preece said that England was very like America in the general desire of the average citizen to be let alone by legislative restrictions, until the need for Government interference is distinctly felt. It was, consequently, necessary to constantly urge the Government action in questions like this. He hoped that the United States Bureau might be established, because Englishmen, who could be reached in no other way, would have their national pride injured by the sending of English ampere-metres to be verified in the United States.

Professor Houston thought that the establishment of such a bureau would have a most useful effect in familiarising the public with the strange terms of electric measurement.

Professor Snyder moved that a committee of seven be appointed to consider the feasibility and manner of establishing a National Bureau of Physical Standards, and report to the Commission before December 1st. After some informal discussion he withdrew his motion to allow of further discussion.

Professor Abbe, of the U.S. Signal Service, was anxious that the barometer should especially be examined. Mr. N. S. Keith stated that unless the measures of electric force were soon legalised a most complicated question would soon be before the courts to determine in the case of legal difficulty concerning electric lighting.

Additional remarks were made by Professors Wead, J. K. Trowbridge, Abbe, Meyer, Rogers, and Prof. Silvanus P. Thompson, of England.

Professor Abbe moved that the Conference approve of the formation of a National and International Bureau of Physical Standards. Professor Rogers proposed as an amendment that a committee of three be appointed to draw up a resolution which should express, if possible, the opinion of the Conference. After considerable discussion the amended motion was carried, and after another motion had been adopted adding Professor Rowland's name to the committee, the chairman named as the committee Professors Rogers, Newcomb, and Wead.

The Congress then adjourned its third sitting till the following day.

From London to Brighton.—It is stated that the United Telephone Company have arranged to lay a tenth line between London and Brighton, which is to be at work in a week or two. Similar communications will be opened between London and the principal commercial centres.

Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending 19th September were £2,875, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended 15th inst., amounted to £3,275.

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A MAGNETO-ELECTRIC PHENOMENON.

By C. V. BOYS, A.R.S.M., Demonstrator of Physics at the Science Schools, South Kensington*.

Every one is familiar with the effect produced when a copper disc is set to spin in a powerful magnetic field; the currents induced by the motion of the disc act in such a direction as to oppose the motion, which therefore speedily ceases. Faraday observed that if, instead of being set to spin, a disc is merely suspended between the poles of an electro-magnet, it will in general be disturbed whenever the current in the coils of the electro-magnet is made or broken. If it lie with its plane parallel or at right angles to the lines of force, no disturbance will be apparent if the lines of force where they are included by the disc are parallel. But if the plane of the disc makes an angle α with the parallel lines of force, then on making the current in the electro-magnet an impulse is given tending to diminish the angle α, while breaking the current gives an impulse tending to increase the angle α.

Again, if the angle α be 90°, so as to eliminate this twisting effect, no movement will be visible at the making or the breaking in a parallel field; but if the disc be placed in a field with diverging lines of force, in which, of course, the strength diminishes as the lines separate, and if it be placed symmetrically so as to include the greatest number (*i.e.*, with its plane at right angles to those lines passing through its centre), then, on making the current, it will receive an impulse causing it to move parallel to itself along the lines of force towards the weaker part of the field, and at the breaking it will receive an impulse more evident in the opposite direction. If this radiating field is produced between a pointed and a flat pole, the disc will, on making the current, appear to be repelled from, and, on breaking, to be attracted by, the pointed pole. So powerful is this effect that a piece of impure copper, which is strongly magnetic, is repelled from the pointed pole on making, and attracted on breaking, the current, thus appearing at first sight strongly diamagnetic.

Though these impulses must have been observed by most experimentalists, their amount has not been, so far as I am aware, determined in absolute units, nor have they been turned to account for making any measurements. As they seem to afford one of the most convenient methods of determining conductivity and field-intensity, perhaps a short paper on the subject, even though it be incomplete, may be of interest to this society.

The explanation of the motions described will be obvious, but it may be well to give it at length for the sake of arriving at quantitative results. In the first place, let the lines of force be parallel, so that the field is of uniform strength. Let a ring of (small) section s, of specific resistance ρ, and of radius r, be placed in the field, with its plane making an angle α with the lines of force. Let the strength of the field be H units. Then during a small increment of field-intensity dH, in the time dt, a current will be induced in the ring of the strength

$$\frac{rs\sin\alpha}{2\rho}\frac{dH}{dt}.$$

This current in the field H will produce a twisting tendency to increase α with a diminishing, or to diminish α with an increasing field, represented by the couple

$$-\frac{\pi r^3 sH\sin 2\alpha}{4\rho}\frac{dH}{dt}.$$

From this it is clear that the couple varies inversely as the time dt occupied in making any small change of field-intensity dH, but it lasts for the time dt; therefore the momentum acquired by the suspended disc, if free to move, will be independent of the rate at which any small change in the magnetic field may be made, but will depend only on its amount, provided that the time is is not sufficient for the angle α to have perceptibly altered during the change. Since this is true of any element, it is true of all; so the momentum acquired by the ring is a direct measure of any total change in the strength of the field in which it lies, no matter by what law it changes in strength. If at the end of any rapid change the field remains of any strength, the motion of the ring will be rapidly stopped by the well-known damping action, of which I shall have more to say later. If, however, the field sinks to zero, or nearly so, the momentum acquired can be measured and the original intensity determined.

The current induced in the ring will of course react on the field and bend the lines of force in such a manner as to hinder their passing through its edge, that is to delay the change of included field intensity; but the impulse is independent of the time or the manner in which the field changes, so it cannot be effected to any extent by this cause.

Since the impulse given to the disc during any element of time is

$$-\frac{\pi r^3 s\,H\sin 2\alpha}{4\rho}\frac{dH}{dt},$$

the total impulse while H changes between 0 and H will be

$$-\frac{\pi r^3 s\,H^2\sin 2\alpha}{8\rho}.$$

If the moment of inertia of the disc be M, and the torsional value of the supporting wire be T, the angular velocity ω generated will be

$$\omega=-\frac{\pi r^3 s\,H^2\sin 2\alpha}{8\rho M},$$

and the throw of the ring θ will be

$$\theta=-\frac{\pi r^3 s\,H\sin 2\alpha}{8\rho\sqrt{MT}}.$$

The action on a disc may be considered as the sum of the actions on the several elementary rings of which it is composed, for there cannot be any tendency for any part of the currents to cross over the elementary circles. The impulse therefore on a disc of radius r and thickness s will be

$$-\frac{\pi r^4 s\,H^2\sin 2\alpha}{32\rho};$$

and the impulse on a disc of radius r_2 with a concentric hole of radius r_1 will be

$$-\frac{\pi s\,H^2\sin 2\alpha}{32\rho}(r_2^4-r_1^4).$$

Since the moment of inertia of a disc is also proportional to the fourth power and to the thickness, so long as the thickness is small, it will appear that the velocity imparted to a disc of any size or thickness, or to a ring, during a change in a magnetic field will be the same. To what extent a correction should be applied to these results for self-induction between different parts of the disc I am not prepared to say; their calculation would give trouble.

For comparing one field with another, discs or rings of metal may be used; but for absolute measurements, as it would be impossible to measure the exact conductivity of a disc, a coil is preferable. By employing discs of different metals their conductivities can be compared without the trouble of drawing into wire or cutting into long strips.

It will be found that a coil of area A and resistance R will, under a torsion T, experience a throw

$$\theta=-\frac{A^2 H^2\sin 2\alpha}{4R\sqrt{MT}}.$$

If, instead of a disc, a sphere be used, no twisting should be experienced if the conductivity in different directions is the same. If, however, there is a plane of greatest or least conductivity, it should be possible to discover it. Crystallisation or mechanical treatment might give rise to such planes in metals; no definite results could be expected in anything else.

I have referred to the apparent repulsion and attraction of a disc of metal by a pointed pole at the making and breaking of the magnetising current. As the lines from such a pole radiate outwards, they are not normal to the metal except in the middle. On their passage inwards or outwards they give rise to circular currents tending to move each part of the disc

* From the *Philosophical Magazine* for September.

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normally to the lines of force. There is therefore a longitudinal component away from the point of radiation during an increase in the field, and towards it during a diminution of the field. A closed coil of wire is subject to the same forces. If a coil be made of uncovered copper wire in the form of a double helix with the ends joined together, and if the convolutions are separate so as nowhere to touch one another, the growth of the magnetic field can be watched by placing the coil nearly over one pole. On making the current the field begins to grow, at first quickly and afterwards more slowly. The coil will receive a push and will extend itself. As the push diminishes in amount, owing to the diminishing rate of growth of the magnetic field, the coil will gradually regain its former shape. It might be thought that the slow recoil is simply due to the damping action of the field: but this is not sufficient to account for it, as when the field is fully grown the coil will, on being forcibly drawn out, recover its shape much more quickly. On breaking the magnetising current, the impulse in the opposite direction, being the same as before but lasting for so much shorter a time, is far more evident.

My first experiments were made with a view to determine whether the impulse was proportional to sin 2α when other things remained the same. I therefore cemented a disc of metal (a half-crown) to an ebonite rod carrying a glass index and hung by a torsion-wire of platinum. The glass index travelled over a card divided into degrees; and the wire to which the upper end of the torsion-wire was soldered also carried a pointer, the position of which could, if desired, be read on a divided card. The disc was suspended between two parallel polar faces of iron. The upper index was turned until, on making and breaking the current, the lower index showed no sign of motion. It could thus be placed within a small fraction of a degree, so that α was either 90° or 0°. The lower card was then adjusted, and the upper index turned so that the lower rested successively at 5°, 10°, 15°, &c., up to 90°. The negative impulse on making, and the positive impulse on breaking, the current were observed by the throw of the lower index. These are given in the second and third columns of the following table. In the fourth column is a series of numbers in the proportion of sin 2α, the largest number being made to agree with the observed positive throw.

TABLE I.

Position of rest.	Negative throw.	Positive throw.	Calculated positive throw.
5	1	4·5	4·6
10	2	9	9·1
15	3	13	13·2
20	4·5	17	17·1
25	5	20	20·3
30	6	22·5	23
35	7	24·5	25
40	7·8	26·2	26·2
45	8·8	26·5	26·5
50	8·5	26·2	26·2
55	8·2	24·5	25
60	7·8	22	23
65	7·5	20	20·3
70	6·5	16	17·1
75	5·5	12·5	13·2
80	3·5	9	9·1
85	2	4	4·6

The close agreement of the other numbers shows clearly that, on breaking the circuit, the impulse is truly proportional to sin 2α. Examination shows that the negative impulses, though in reality equal to the others, are apparently much less in amount, that they are not even in proportion, and not only this, but that the corresponding values on either side of 45° are not the same. This want of symmetry is clearly shown by Fig. 1. The discrepancy is due to the fact that the disc is brought to rest by the damping action of the field as well as by the torsion of the wire, and that the damping action is greater as the angle is less, being $::\cos^2 \alpha$.

I thought it would be interesting to determine to what angle the disc would be thrown if the torsion of the wire did not act. I therefore suspended, instead of the disc, the coil used in the absolute experiments by a silk thread, adjusted the lower card by the method of no throw, and brought the index to rest successively over 10°, 20°, 30°, &c., up to 90°. The

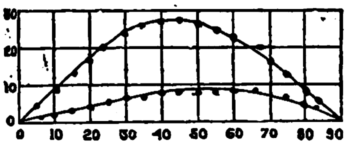

FIG. 1.

index came to rest at the series of positions shown in column 2 of the following table:—

TABLE II.

Pointer fell		Pointer fell	
From	To	From	To
10	3·6	50	18
20	6	60	22
30	10	70	29
40	13	80	39
45	16		

The same results are shown graphically in Fig. 2. It is interesting to note that the curve shown is a natural curve depending on circular functions only. It is independent of the nature of material, such as conductivity, moment of inertia, or of the strength to which the field is made to grow from zero. It is subject to a small error, for I did not destroy the residual magnetism. That the effect of this is appreciable is evident, for in one series of experiments with a disc the throw on making was always from 45° to 33°; but the first time that the direction of the magnetising current was changed the throw was from 45° to 35°, after which it was from 45° to 33°, as before. This diminution at the first reversal was always the same. I found almost the same fall with the half-crown as with the coil, and with one cell as with ten cells. There were slight differences, but not more than draughts from which I did not shield the needle would have accounted for. The lower angle can be read with precision, but the higher angles become difficult to observe as the damping influence diminishes. The position $\alpha = 90°$ is one of instability; for however slight a velocity is given to the disc, it will not be brought to rest for a considerable time, owing to the very minute nature of the squares of the cosines of angles, nearly equal to 90°.

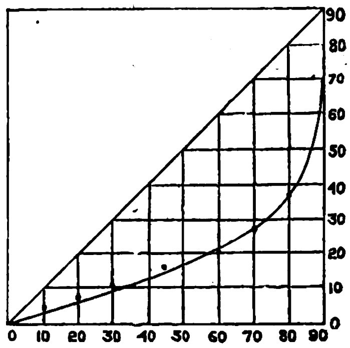

FIG. 2.

The last series of experiments was made with a view to determine whether the strength of field determined by observation of the throw of the disc at breaking agreed with the strength determined by some recognised method. I therefore made a small coil of twelve turns of copper wire of 1·45 centim. radius and with a resistance of 0·085 ohm. The area of the coil was 79·4 square centim. The moment of inertia of coil and index was found by comparison with a cylinder to be 58·1 units, and the torsional value of the sup porting wire to be 17,000 units. The plane of the coil was

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adjusted by the usual method to zero, and then set to 45deg. The currents from 10, 9, 8, &c., to 1 Grove cells were sent in succession through the coils of the electro-magnet and through a Siemens electro-dynamometer. The following table shows the amounts of the positive and negative impulses, the strengths of the magnetising currents in amperes, and the field-intensities calculated from the positive throws by the formula

$$H^2 = 9311000 \times \text{Throw measured in degrees.}$$

TABLE III.

Number of cells.	Magnetising current in amperes.	Negative throw.	Positive throw.	Calculated field in absolute units.
10	11·85	10·5	27·5	16,000
9	11·2	9	26	15,600
8	10·44	8·2	24·5	15,100
7	9·47	7	22·5	14,500
6	8·63	6	21·3	14,100
5	7·60	4·8	19·2	13,400
4	6·53	3·3	16·5	12,400
3	5·18	2·2	13	11,000
2	3·67	1	8	8,630
1	1·83	0·2	2·8	5,070

The ends of the coil which were soldered together were then unsoldered without disturbing the soldered connection between the torsion wire and one end. The other end was bent so as to dip into a small mercury cup in the axial line, so that a known current, measured by a second electro-dynamometer, could be sent through the coil. During this change no part of the apparatus was moved at all; it was, however, necessary to redetermine the zero position, which was now rather more difficult, for the resistance of the torsion wire was so great in comparison with that of the coil alone, that the throw at any angle was only about one-tenth of what it was before. As before, the current from 10 to 1 cells was sent successively through the coils of the electro-magnet and an electro-dynamometer. The current from a Daniell cell was sent through the suspended coil and measured. In the fourth column of the following table will be found the deflection of the coil due to currents tabulated in columns 2 and 3. In the fifth column is the deflection due to the residual magnetism; and in the sixth column the strength of field in absolute units, calculated from the formula

$$H = \frac{3{\cdot}73 \times \text{deflection in degrees}}{\text{deflecting current in absolute units} \times \cos \delta}.$$

TABLE IV.

Number of cells.	Magnetising current in amperes.	Deflecting current in amperes.	Deflection = δ.	Deflection due to residual magnetism.	Calculated field in absolute units.
10	11·92	·514	65	4	11,200
9	11·05	·530*	64	4	10,260
8	10·52	·502	63	4	10,320
7	9·48	·496	62·5	4	10,150
6	8·63	·480	61·5	4	10,050
5	7·60	·480	60·3	4	9,470
4	6·45	·480	59	4	8,930
3	5·14	·480	57	4	8,120
2	3·67	·480	51·5	4	6,470
1	1·98	·480	40·5	4·5	4,140

* Obviously over-estimated, hence small results.

The residual magnetism was always the same till one cell only had been employed to excite the electro-magnet, when the deflection was clearly greater. This I repeated several times with one and with more than one cell. A deflection of $4\frac{1}{2}°$ was always obtained from one cell, and of 4° from more than one cell. To obtain a still higher residual magnetic effect, I drew the terminal along a fine wire, and gradually diminished the field; by this means I obtained a residual field giving a deflection of 5°·4. The magnetic fields corresponding to the deflections 4, $4\frac{1}{2}$, and 5·4 are 312, 352, and 422 absolute units.

Fig. 3 shows the field intensity measured by the two methods. They do not agree, nor are they quite proportional, nevertheless they are of the same order of magnitude. The discrepancy is greater than would be expected from errors of an experimental kind, even though the apparatus was hastily improvised. Nevertheless the agreement, such as it is, shows that it will be worth while to carry out a series of experiments with the accuracy and care that are needed in physical investigations. This I intend to do as soon as I am able. It will

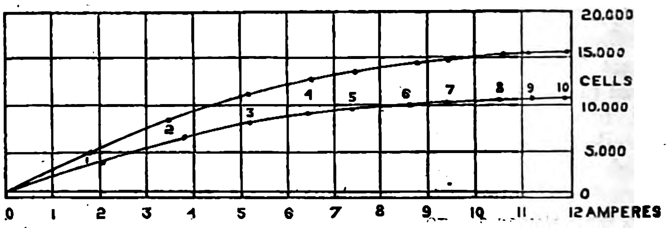

FIG. 3.

then, perhaps, be possible to tell whether this method of determining conductivity or field-intensity is to be relied upon; it certainly, in convenience and simplicity, compares very favourably with any of the usual methods.

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TELEGRAPHS.

COMPANIES.	CLOSING PRICES. SEPT. 24.		BUSINESS DONE WEEK ENDING SEPT. 24. Highest.	Lowest.
Anglo-American	81,	82	82	81
Do. Preferred	55,	56	56	54⅞
Do. Deferred	6¾,	7¼	7⅛	7
Brazilian Submarine	11¼,	11½	11⅛	11¼
Cuba	10¾,	11¼	11	—
Do. Preference	17,	18	17⅝	—
Direct Spanish	3¾,	4¼	3¾	—
Do. Preference	15,	15½	—	—
Direct United States Cable	9¾,	10	10¼	10 1-16
Eastern Telegraph	11½,	11¾	11¾	11 9-16
Do. 6 per Cent. Preference	13½,	13¾	13¾	13 7-16
Do. 5 per Cent. Debentures, 1899	104,	107	106	—
Eastern Extension	11⅞,	12⅛	12⅛	11⅞
German Union	9¾,	10¼	10	—
Globe Telegraph and Trust	6⅞,	7⅛	7⅛	6⅞
Do. Preference	12⅝,	12⅞	12⅞	12⅝
Great Northern	13½,	13¾	13¾	13½
Indo-European	32,	33	—	—
Reuter's	8,	8½	—	—
Submarine	170,	180	178	—
West India and Panama	⅞,	1⅛	5-16	—
Do. 1st Preference	7½,	7¾	7½	7⅝
Western Brazilian	6¾,	7	7⅛	6⅞
Western Union 7 per Cent. 1st Mortgage	123,	125	—	—
Do. 6 per Cent. Sterling Bonds	100,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	¼,	⅜	—	—
Oriental	⅛,	⅜	—	—
United Telephone	13¼,	13¾	13⅝	12

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1⅛,	1⅜	1¼	—
Do. (fully paid)	2¼,	2¾	—	—
Hammond Light (£3 15s. paid)	⅛,	⅜	5-16	—
Swan	—	—	—	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	32½,	33½	33⅛	33
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23½	23⅛

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NOTES.

THE JABLOCHKOFF COMPANY.—This company's offices are now removed to the factory, No. 36, Albert Embankment, Lambeth, London, S.E.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 26th ult. amounted to £3,356.

ELECTRIC LIGHT AT ROTTERDAM.—It is proposed to install the electric light at the Dutch port of Rotterdam, and maintain it by means of accumulators.

KING'S COLLEGE.—We understand that an evening class in practical physics is to be conducted by Mr. A. P. Trotter during the forthcoming winter session.

ELECTRIC LIGHT ON BOARD STEAMERS.—The Cunard Company's new liners, the "Umbria" and "Etruria," are provided throughout with the incandescent form of the electric light.

ELECTRIC LIFTS.—Electricity is now being largely used in the great towns of America for working lifts, the current being either supplied from a central station, or from a dynamo on the premises.

TELEGRAPH REVENUE.—The telegraph is one of the only three items of revenue which have yielded an increase during the financial half year just ended; but the sum is very small, being only £5,000.

COMMUNICATION WITH CHINA.—Owing to the stoppage of the Saigon and Hong Kong cable, the lines of the Eastern Telegraph Company and of the Indo-European Telegraph Company to China are interrupted.

ANTWERP EXHIBITION, 1885.—The cost of motive power for driving machinery has been fixed at 20 centimes per French horse-power (0·986 horse-power), which is as nearly as possible 2d. per horse-power per hour.

ELECTRIC LIGHT AT THE ODESSA EXHIBITION.—An exhibition of Russian and foreign products was opened at Odessa last week. In the evening, the numerous pavilions and *parterres* are illuminated by the electric light.

FOOCHOW.—The Post Office notify that telegrams may be again accepted for Foochow, at the sender's risk, to be forwarded from Sharp Peak, the place where the cable lands, by steam launch which runs daily to Foochow.

ELECTRIC LIGHT AT DUNDEE.—The rooms in which the Fine-Arts Society of Dundee is to hold its Exhibition are to be illuminated electrically by the Anglo-American Brush Electric Light Company, with a No. 8 Brush arc machine and lamps.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 26th September, were £2,688, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

ELECTRIC LIGHT IN HUNGARY.—Last night, says the *Standard's* Pesth correspondent of Tuesday, the town of Temesvár was, for the first time, lighted with the electric light. A complete installation on the Brush system has been laid down for the permanent illumination of the place.

THE DISCOVERERS OF ELECTRO-MAGNETISM.—Our contemporary *Cosmos*, a new and enlarged series of which has just been commenced, complains that Lord Rayleigh, President of the Montreal Congress of the British Association, omitted the name of Ampère from the discoverers of electro-magnetism.

ELECTRIC LIGHT IN THE EAST RIDING.—The Brush Company have received instructions from the Driffield and East Riding Oil Cake Company to light their oil works. The plant to be employed consists of a D2 Victoria incandescent dynamo, 130 Victoria incandescent lamps, and all the necessary cable, switches, and other plant.

THE CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of September was 2,644, estimated to produce £2,150, against 2,656 messages, producing £2,515 in the corresponding month of last year. The traffic receipts for the month of June, estimated at £3,150, realised £3,168.

ELECTRIC LIGHT IN FINLAND.—The Anglo-American Brush Company has received an order from Finland for the necessary plant to light the theatre at the town of Bjorneborg. The plant to be employed will consist of a D 2 Victoria compound-wound machine, 130 Victoria incandescent lamps, and the necessary cable, switches, cut-outs, and fittings.

THE ELECTRICAL RESISTANCE OF ALUMINIUM.—The electrical resistance of aluminium commercially pure is 1·96 that of pure copper, while the addition of a small quantity of aluminium to copper greatly increases its resistance, both electrical and mechanical. For wires of equal length and weight, the resistance of aluminium is a little less than that of copper.

UNIFORM MERIDIAN.—The International Prime Meridian Conference was opened at Washington on Wednesday. Forty delegates were present, representing twenty-two countries, and were welcomed by Mr. Frelinghuysen. Count Lewenhaupt, the Swedish Minister, acted as temporary chairman. Admiral Rodgers, of the United States navy, was elected permanent chairman.

FRENCH POSTAL TELEGRAPH REVENUE.—The receipts from the telegraphic service during the first six months of the present year were 13,150,600f., or 907,400f. less than the estimate for that period. A similar and larger falling off has occurred in the French Post Office receipts. This coincides with the state of things in Lower Austria, which we recorded last week.

REVOLUTION CAUSED BY THE ELECTRIC TELEGRAPH.—In a recent article on scientific discoveries, *The Times*, after commenting on the change in trade brought about by railways, says that a revolution has followed, much more quickly, through the extension of the electric telegraph to every capital of importance in the world, and to nearly all the minor centres of trade and production.

THE BENNETT-MACKAY CABLE.—The "Faraday" is reported to have commenced laying the last section of the second Bennett-Mackay cable, making steady progress in face of unfavourable weather, and being likely to finish her task very shortly if all goes well. We learn that, after completing this work, the "Faraday" will proceed to lay the connecting cable from Canso, Nova Scotia, to New York City.

ELECTRIC LIGHT IN PARIS.—Hachette et Cie, the large firm of publishers and booksellers in Paris, with branch in London, have had their folding and binding departments in the Rue Stanislas lighted by incandescent lamps for two years

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past. So satisfied are they with the results, that they have now arranged to extend the electric light to the whole of their establishment, and have ordered 350 Edison lamps.

ELECTRIC LIGHT REGULATOR.—M. Roussy, proprietor of the Gilamont Mills, near Vevey, which have been illuminated by the electric light on the Edison system upwards of two years, has invented a governor, which permits of regulating, at pleasure, the intensity of incandescent lamps. The contrivance, which is attached to the lamp holder, is said to be remarkably simple and easy to work, while scarcely increasing the first cost of the lamp.

POPULAR LECTURES.—A course of weekly lectures, accompanied by class teaching, will he held during the coming session (October-December, 1884) in connection with the London Society for the Extension of University Teaching, as under:—Electricity, at Highbury; Some Physical Properties of Air and Water, at Whitechapel. The lecturer will be J. W. Waghorn, D.Sc., R.N., Instructor in Physics at the Royal Naval College, Greenwich.

VOLUNTEER TELEGRAPHISTS FOR EGYPT.—We are informed that every one of the 50 Post Office telegraphists incorporated in the Army Reser ve volunteered their services for Egypt—a fact which is highly creditable to the spirit of the men and to the corps they honourably represent. The twelve men finally selected sailed in the "Deccan" last week. Five came from the Central Station, one from the Metropolitan District, one from the London Telegraph School, and the remaining five from provincial offices.

DIRECT UNITED STATES CABLE COMPANY.—This company notifies that the £100,000 six per cent. debenture loan of the company, falling due on the 15th October next, will be repaid on and after that date at the Consolidated Bank (Limited), 52, Threadneedle-street, London, E.C., together with the interest then due. The debentures, which will cease to carry interest from 15th October next, must, with coupons attached, be left for examination at the Consolidated Bank three clear days prior to application for payment.

THE DOVER-CALAIS CABLE.—In the splendid armoury of Turin, amongst war-like implements of all sorts and of all ages, surrounded by warriors armed *cap-à-pie* on prancing steeds (stuffed), there is to be seen, in a glass case, a piece of the old Dover-Calais cable which had been presented to the King of Italy years ago. It is carefully labelled, and its weight is recorded in a corner of the label. Probably the donor or the museum authorities thought that the merits of the sample, about a foot long, were commensurate with its weight.

MORE BALLOON STEERING TRIALS.—The *St. Petersburg Herald* states that a formidable Russian rival to the experimental balloon at Meudon is in the field. Captain Kasztowitz is building at Okhta a large cigar-shaped balloon, 200ft. in length and 80ft. in height, including the car, which he has furnished with a screw and also with wings. He considers that he will be able to take a crew of 16 men and 250lb. of ballast at the rate of 40 German miles an hour. The experimental trip is expected to take place early next month.

CHESS BY TELEPHONE.—There have already been international chess matches played by means of the telegraph; and it is probable that the moves were communicated by a concealed player to the famous chess-playing automaton, Ajeeb, by means of the electric current. Now, however, we learn that an eight-board chess match was played on Monday night between the Bradford and Wakefield clubs. The games were completed without delay, in four hours, by sixteen players, the moves being transmitted by telephone along twenty-five miles of wire.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—At a meeting of the directors held on Wednesday last it was decided, subject to final audit, to place £10,000 to reserve, and to recommend to the shareholders at the approaching meeting that a dividend of 6s. per share be declared on account of arrears of dividends on the first preference shares. The estimated traffic receipts of this company for the half month ended the 30th September were £1,987, as compared with £2,299 during the corresponding period of 1883. The June receipts, estimated at £6,066, realised £6,196.

DEAL.—The Mayor and Corporation of Deal, a small but growing seaside resort on the east coast of Kent, have wisely decided to adopt the electric light both for public and private lighting. The Deal and Walmer Electric Light Company (Limited) have decided on working the light on very economic principles to ensure its being a success. Two of the principal items in the cost are eliminated, for the manager, Mr. H. G. Frost, and the secretary, Mr. Carterfield, have decided not to accept any remuneration for the offices they fill for the first twelve months at least; and, as the manager is a thoroughly practical man, we feel sure that nothing but success can ensue.

A NEW FORM OF MAGNET.—A fairly powerful magnet is credited to Signor B. Ricco, of Palermo, who surrounds a soft iron core with a long band of sheet iron, having oiled paper between the coils for insulation. One pole is put in connection with the core, to which the internal extremity of the sheet iron band is soldered; and the other pole with the external extremity of the band. The electric current magnetises not only the core, but also each coil of the band, which thus acts both as conductor and as magnetic substance, thereby condensing the lines of force and causing a great concentration of power. Magnets of this form have been used to our knowledge for several years past in this country.

ELECTRIC LIGHT IN THE NAVY.—We learn that the Anglo-American Brush Corporation have received an order from the Admiralty to fit out H.M. ss. "Reindeer," "Cleopatra," and "Linnet," with electric light apparatus. The plant to be employed on each vessel will consist of a D2 Victoria compound-wound incandescent machine, capable of producing a search light of 25,000 actual candles, one of Brotherhood's new and improved 3-cylinder direct-acting engines, and a 60 cm. projector, fitted with inclined hand lamp. The dynamos are of the special slow-speed type designed by the corporation for ship lighting, and will be driven at a speed of 600 revolutions per minute.

POWERFUL LIGHTS IN FOGS.—It has been stated, upon reasonably good authority, in connection with the South Foreland Lighthouse experiments, that, whereas in clear weather the powerful electric light has proved incomparably more brilliant than the oil and gas burners tried with it, it does not hold its own in foggy weather, when the gas-lamp becomes the most visible of the three lights. This statement, of course, proceeds from unofficial observers; but it agrees with common experience. So says the *Journal of Gas Lighting*. But we may venture to ask if the electric light has really been tested in foggy weather? In the experiments, have any specially prepared carbons been used to obtain effective fog penetration? Let us assume that rays at a certain part of the spectrum pass more easily through

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fog, yellow rays for example. Have carbons treated with sodium been tried? Have incandescent lamps been tried? And so on. Till such trials have been made we maintain that the whole series of tests are of little real value.

METAL DEPOSITS.—By modifications in detail, introduced into his electro-chemical processes, M. Weill has succeeded in coating, instantaneously, at the ordinary temperature, and by means of a single battery, all the ordinary metals and their alloys with a thin adhesive coating of brass, which presents at will the brightest and most varied colours. The operator, by modifying an electric action produced without separate battery, obtains at pleasure, on the same object, solid deposits of various hues and extreme brilliancy. It appears that the varied tints are due to the formation of several copper oxides, the composition of which is not yet determined. The coating is of such slight thickness that it can be applied to all metals, and in no way detracts from the sharpness of outline of the most delicate jewellery, to which it gives curious and often very appropriate hues. Ornaments cast in iron or stamped out in sheet iron may also be treated by this process.—*Bulletin de la Compagnie Internationale des Téléphones.*

ELECTRIC LIGHT IN THE BALL ROOM.—The American Crœsus, George Gordon Bennett, lately gave a big masquerade ball at his Newport villa, in honour of President Arthur, who was his most honoured guest. Rare Ben Jonson's masques in the Elizabethan age must have been considerably thrown into the shade, for we learn that electric lamps were profusely distributed about the grounds, and within a large ball room improvised of canvas for the occasion. At one end, from out of a mimic iceberg, composed of twenty tons of ice, issued tiny streams, led by concealed pipes, and falling into "a clear lake," which, if not "margined by fruits of gold," was artfully and artistically illuminated by masked electric lights. At the other end, a huge pyramid of maiden hair was surmounted by the flags of the "Namouna," the host's large steam yacht. The reduction of temperature by the iceberg is said to have rendered dancing enjoyable by the 600 guests, although the thermometer in the rest of the grounds stood at 80°F.

ELECTRIC CURRENT GENERATED BY DRIVING BELTS.—From time to time this one phase of frictional electricity crops up like the big gooseberry during the dull season. It is now reported that Herr Bacher, lighting inspector at the Dresden Opera House, has, in a few seconds, charged a Leyden jar with the electricity generated by a machine belt, and that its discharge produced sparks nearly three-sixteenths of an inch long; and, further, that a person, standing on a stool insulated with glass legs, drew powerful sparks from the belt by bringing his finger-top within a distance of about half an inch. After all, this is but one of the countless manifestations of the generation of electricity by friction with which we were made familiar in childhood by rubbing a piece of sealing wax on blotting paper, and finding it would attract light substances; and also by eliciting sparks on rubbing a cat's back the wrong way in the dark. Darkness was a condition of occular demonstration, and therefore of belief. If we had been told that the sparks were produced with equal intensity in the daytime we should not have believed it.

LONG DISTANCE TELEPHONING.—Last week some experiments were made, under the auspices of the United Telephone Company, in telephoning from the Grosvenor Hotel, near the Victoria Station, to Dover. We learn that messages from this town were distinctly heard in London, but the attempt to hear messages sent from London to Dover and back was not successful. The experiments were much interfered with, owing to the wire used being that on which the London, Chatham, and Dover Railway Company send their block-system service messages between London and Dover, which interrupted the telephonic communications. But why does not the company adopt the Van Rysselberghe system, as now being applied in Belgium, which permits of telegraphic and telephonic messages being sent simultaneously along the same wire? Intelligence has since reached us that on Monday last messages were spoken from Reading to Weymouth, a distance of 141 miles; and on Wednesday, by special arrangement with the Post Office, a G.P.O. wire from St. Martin's-le-Grand to Liverpool was connected with telephones, when messages were thus sent over 200 miles.

ELECTRIC LIGHTING AT HYDE PARK, BELFAST.—A most successful installation has just been carried out at Hyde Park, the well-known bleach green of Messrs. Fenton and Connor, Belfast. The installation has been effected in the upper works, and by means of some 130 20 candle-power incandescent lamps, the main portion being distributed in the stoves, finishing, old beetle and patent beetle rooms; but, in addition, lamps have also been introduced into the engine room, boiler house, circular saws, turning, and carpenter's shops, as also into the stores and offices. The first trial was made on Monday night, with such success that extensions were ordered the same evening into the browning rooms, situated in the lower or wet works some little distance off, and the question of the introduction of the light into every portion of the building is under consideration. The cables and wires are from Messrs. Callender and are encased almost throughout, while the lamps and dynamo are Brush Victoria. The installation has been carried out by the Belfast Electric Appliances Company (Limited), under the supervision and arrangement of Mr. G. Annesley Grindle, their engineer and manager.

THE TELEPHONE IN THE POTTERIES.—A meeting, presided over by Mr. J. N. Peake, chief bailiff, was lately held at Tunstall, to consider some proposals for establishing a telephone exchange, emanating from the North Staffordshire Chamber of Commerce. Mr. F. W. Neale, telegraph engineer, said that, if he undertook the work, each town would be provided with a centre, with which any subscriber of £12 per annum in the parliamentary boroughs of Stoke and Newcastle, without distinction as to distance, could be placed in communication; and, should he have two or more places of business in the several towns comprised in the said boroughs, the subscription for each would be reduced to £9. With respect to existing contracts with different firms, special arrangements would be made, so that they would not have to pay more than the above-named amounts. It would not be necessary to wait until a certain number of subscribers was guaranteed, as they were sure to increase on the public seeing its interest in the matter. Mr. Neale also proposed that, as soon as the project was fairly at work, the police stations should be put in communication at cost price, and that, when the exchange was closed at night, communication between each town should remain established, in case of fire or other emergency. The chairman expressed himself satisfied with Mr. Neale's statement, for which he proposed a vote of thanks; and the meeting was adjourned for a month to see what course other towns would take in the meantime.

THE S.S. "SAN MARTIN."—INSTALLATION OF THE ELECTRIC LIGHT.—The new screw-steamer "San Martin," built by Messrs. Napier, Shanks, and Bell, the well-known Clyde firm

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for the Lloyd-Argentino Steamship Co., and now lying in the Queen's Dock, has been lighted throughout with the electric light, the installation being made by the Edison and Swan United Electric Light Company. The electric light is now comparatively common on board ships, all first-class vessels being fitted with it. The Edison-Swan Company alone have fitted out 50 passenger ships, and by the experience thus gained they have been enabled to perfect their system, and overcome many difficulties which beset them in the earlier days of electric lighting. In the "San Martin" the motive power is supplied by a 10 h.p. Tangye engine, which, by means of a cotton rope, drives a 200-light Edison-Hopkinson dynamo. The wires which convey the current from the dynamo room to all points of the ship are placed behind mouldings, suitably combined in harmony with the general decorations of the ship. The total number of lights is 157. Each state room is furnished with a light, and provided with a switch by which the passengers will have control over it. The dining saloon is well lighted by two-light pendants supplied by Messrs. M'Geoch and Co. The whole of the work has been completed under the inspection and to the satisfaction of Señor Brugo, president of the Argentine Company, by members of the Edison-Swan staff.

Electric Light at Brighton.—We learn that the Executive Committee of the Art Loan Exhibition to be held in the Corn Exchange, Brighton, are desirous that that building be lighted by electricity during the exhibition. Hearing that the motive power on the premises is not sufficient to permit of the efficient illumination of the whole of the property, they applied to the Pavilion Committee for authority to obtain current from some other source. This committee has authorised the Exhibition Committee to make arrangements for obtaining current from a source outside the Pavilion, stipulating, however, that all the wires and apparatus on the Pavilion estate be fixed to the satisfaction of the borough surveyor and of the insurance companies. The committee made a strong recommendation in favour of the arrangement for the extra amount of current being entrusted to Mr. Magnus Volk, electrical engineer, of Brighton. On 22nd ult. the Gas Committee took in hand the question of an improved lighting for the front of the town, and passed the following resolution:—"That the Electrical Sub-Committee be requested to visit Colchester for the purpose of inspecting and reporting upon the system of electric lighting in operation in that borough; that they be also authorised to visit other towns where systems of electric lighting are in operation; and that a sum not exceeding £50 be set apart to defray the expenses of the deputation." We learn that the sub-committee have secured the services of Mr. Volk to aid them in their inspection.

On Unequal Electric Conduction Resistance at Cathodes.—Dr. G. Gore, F.R.S., in the *Proceedings* of the Royal Society, says:—"During some experiments which I have been making on the unequal resistance to the deposition of a metal upon cathodes of different metals in the same solution by the same current (*see* "Some New Phenomena of Electrolysis," vide *Electrician*, May 31, 1884), I have been led to investigate the resistance of cathodes of different metals to the passage of the current into them. I have found that by taking a good conducting electrolyte, immersing in it a positive sheet of zinc, and a smaller negative one of another metal, connecting the plates with a galvanometer of low resistance, reducing all the other resistances in the circuit to the minimum except that of the negative plate; then making a series of measurements of strengths of current of different couples formed by the zinc and about 12 other metals, during removal of polarisation by stirring the liquid; also making another series of measurements of the electromotive forces of the same couples during stirring; calculating from these data the total resistance in each case, then deducting the portion of resistance due to the galvanometer, also that due to the liquid itself, and to opposing contact-potential, and thermo-electric and voltaic action at the cathode and external junction, very different amounts of resistance, large in some cases, remain, and are exercised by different metals as cathodes, and those differences of resistance are only to a small extent due to heat and current absorbed in liberating hydrogen, and can only in a few cases be partly accounted for by chemical action, films, or absorption of gases at the cathode. I am now investigating the nature of this resistance, and the relations of the resistance to various circumstances."

Franks' "Granule Carbon" Battery.—In a paper on the application of electricity to illumination in astronomical observations, Mr. W. S. Franks, of Leicester, records in the *Journal of the Franklin Institute* experiences with incandescent lighting by battery power. His requirements in the matter of lamps were not large, as he only used two of Swan's 2½-candle type, supplied at first by a 4-cell bichromate battery of the usual kind. Ultimately, however, Mr. Franks decided upon a type of home-made battery, which may readily be made by any one connected with gasworks wishing to make a private trial of incandescent lighting on a small scale. The outer cell is a wide mouthed, two-gallon salt-glazed stoneware jar, in which is placed a carbon plate, sawn out of the raw material as obtained at gasworks, its rough edges being merely cut true. There is also a porous cell containing a zinc plate; and both cell and carbon plate are packed into the jar with pieces of carbon broken to the size of a small nut. The jar is then charged with 1lb. of bichromate of potash, dissolved in 1 gallon of hot water, with 1lb. of sulphuric acid afterwards added, while the porous cell is charged with dilute sulphuric acid, in the proportion of 1 to 10. The three cells are coupled for intensity. When not in use, the zincs are lifted out of the liquid and suspended, by loops in the insulated wire connections, upon small nails. The only preparation of the carbon plate was to thoroughly paraffin the exposed end, and place a small clip of platinum foil on it, under the brass clamp, which effectually prevented the destruction of the clamp by acid creeping up the pores of the carbon. It is stated that, for the usual intermittent observatory work, the cells will last for three months without recharging; though, when required, the lamps can be kept up to full incandescence for hours together. In the ordinary way Mr. Franks puts down the expense at about 3d. per week on an average.

The Woolley Electric Headlight for Locomotives.—We have already referred, on two occasions, to the Woolley electric headlight for locomotives, in use on the Chicago, Milwaukee, and St. Paul Railway; and the following particulars, furnished by Mr. Lowry, general master mechanic of that line, will be read with interest:—"We are experimenting with what is known as 'Woolley's' patent electric headlight, and for your information I will add, the engine and dynamo are placed on the running board on the left-hand side of the locomotive, opposite the air-brake pump, which is located on the right-hand side. They (engine and dynamo) occupy a space 34in. in length by 10in. in width. The dynamo is 18in. square by 10in. high. The armature is made up of discs, and is 12in. long by 6in. in diameter. The power is furnished by a small rotary engine, built by the Noteman Engine Company, of Toledo, Ohio, which runs six hundred revolutions per minute. The engine is connected to the

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shaft of the armature direct, the governor being on the opposite end of the shaft. There are no belts or gears of any kind. The dynamo is closed, so that it cannot be injured by the weather, &c. The lamp used is a focusing arc lamp with an ordinary locomotive reflector. The lamp is made so that it can be regulated from the cab of the locomotive. The light is a good one; it is claimed it will penetrate so far into darkness that, should the track be obstructed from any cause and a locomotive with the light on it be running at the rate of 50 miles per hour, an obstacle can be discovered sufficiently ahead that the locomotive can be stopped in time to avert a disaster. I might add furtherthe machines are built by the Woolley Locomotive Headlight Company, Indianapolis, Ind. The power of the lamp I have referred to is 2,000 candle-power. It has an attachment to counteract any quick movement, so that any sudden jar of the locomotive does not affect the light in the least."

ELECTRIC SYNCHRONISM.—In the current number of the Society of Telegraph Engineers' *Journal* is the following abstract of a paper by M. Deprez:—"The apparatus proposed by the author consists of two parts, the so-called 'annular comparative instrument' and a special form of magneto-machine. The latter has a ring of the Paccinotti type arranged between the poles of the magnet, which is free to rotate as well as the ring. Four brushes are used, arranged at right angles, and thus dividing the commutator into four quadrants; two brushes at opposite ends of the same diameter are joined up to the comparative instrument, which consists of a fixed iron ring with two windings of wire, split up in such a way that the successive sections alternately form part of one or the other winding. If two electric currents of different strength are passed through this instrument, four poles will be formed on the circumference of the ring, the lines joining which will be at right angles; but the magnetic forces exerted in their direction will combine to form a resultant, the position of which will depend on the proportion of the two currents, and not on their absolute strength. A magnetic needle suspended at the centre of the apparatus will place itself along this polar line. If now this 'annular comparative instrument' be joined up to the Paccinotti ring, and the ring rotated while the magnet remains fixed, the same result will be attained as though the ring rotated inside two distinct magnetic fields. Now each pair of brushes will collect separately the current due to the magnetic influence of the perpendicular component at its line of contact, and the comparative instrument will be traversed by two currents of different strength, which will cause the magnet needle to take up a definite position. Suppose this the initial position, now rotate the magnet, leaving the brushes fixed; then to every angle described by the polar line will correspond a definite value of the ratio of the two components of the magnetic field, and therefore of the two currents produced. It may be concluded that if the brushes and the magnet are rotated at different rates, the comparative instrument, which may be placed anywhere, will show the relative displacement of the two. To adapt such an apparatus for use as a compass, the axis of the rotating ring is placed vertically, and the inducing magnet is done away with, being replaced by the natural magnetic field of the earth. The resultant of the earth's magnetic force at a point can be resolved into two components, the one being a horizontal projection of the resultant, and coinciding with the magnetic meridian—this force replaces the permanent magnet; the second is vertical to the former, and therefore without action on the ring. If, then, the brushes remain fixed, any change, however small, in the magnetic meridian will produce a corresponding change in the comparative instrument. This latter may be placed in any convenient position, while the ring may be placed at the mast-head of a ship, out of the way of all influence due to the presence of masses of iron."

STEAM SHIP ELECTRIC LIGHTING ON THE WEAR.—The Hammond Electric Light and Power Supply Company have fitted one of Mr. James Laing's new vessels (No. 295) with a most complete system of incandescent electric lighting, consisting of a duplicate plant for 150 20 candle-power lights. Each plant consists of a Westinghouse high-speed single-acting engine and a new pattern slow-speed Ferranti dynamo and exciter, coupled together and mounted on one base plate, and running at 600 revolutions per minute. The Westinghouse is one of the most practical forms of high speed engines. Those used have two cylinders, 9in. bore and 6in. stroke, steam acting on one side of the piston only. All wearing parts are kept constantly in compression, and knocking therefore cannot occur. The generators have been specially designed for ship lighting, the slow speed making it practicable to couple direct to engine, all risks due to intermediate gear being dispensed with and the space required brought down to a minimum. All parts are to gauge and be interchangeable, the wearing parts being arranged so that they can be replaced by any ordinary mechanic, as the electrical parts of the machine have been made permanent and free from wear. Another feature is the extreme lightness of the revolving parts of the machine, which is of first consequence in ship lighting plant, on account of the roll of the vessel at sea. The engines are coupled to the dynamos by means of new flexible couplings, so that none of the vibration on the crank shaft is communicated to the dynamo. The oiling arrangements have been very carefully worked out, so as to reduce the attendance to a minimum. From one elevated oil vessel all the parts are oiled through a system of pipes, a small valve being placed at each bearing to regulate the supply to each part. After passing the valve, the oil is visible as it enters the bearings. In case of heating, the valve can be fully opened; and the pressure due to the elevation of oil vessel will force oil through and cool down very quickly. The wires have been specially prepared for the company to suit this class of work, and are well protected throughout from all external injury. A great source of trouble has hitherto arisen in ship-lighting from the lamps shaking loose in their holders, through the vibration of the vessel. This is obviated by a new type of holder, which is fitted to all the lamps, and is self-locking. This holder is mechanically very strong, and does away with the breakage of the platinum loops so common to the ordinary method of fixing incandescent lamps. The lamps are run in parallel arc, the E.M.F. being 100 volts. The current to all parts of the vessel is controlled by switches fitted to each lamp or group. These switches are efficient, elegant, and simple. The special feature is that the contact surfaces, when making or breaking, neverleave each other, but wear smoothly together, keeping the surfaces bright and clean; they break simultaneously at two points, without any jerking action caused by the surfaces separating. All the parts are made by special tools, and are exact duplicates of each other. Each lamp or group is also fitted with a safety fuse, to protect the wires in case of accident to any branch. The two plants are set side by side in a small recess of the engine room, measuring 12ft. 6in. by 7ft. 6in. by 6ft. only, open to the engine room, and allowing a passage round the back to get at any part of the plants. The stop valves are placed together and close to a switch-board, so that the engineer standing in one place can start and stop the engines or put either plant on to part or the whole of the circuit.

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THE BRITISH ASSOCIATION MEETING AT MONTREAL.

The meeting at Montreal is over, and every one is pleased with the result. There were 1,773 members, and £1,800 was added to the funds of the Association. £1,500 was distributed in small sums to carry out the object of the Association, viz., the advancement of science. Six hundred old members turned up, a number that compares very favourably with the average attendance. The hospitality of the inhabitants of Montreal was unbounded, and nothing whatever occurred to mar the relation between guests and hosts, though several members in England had accepted invitations to stay with people, but did not turn up, nor wrote, nor telegraphed, so deprived their colleagues of comfortable quarters, and were guilty of rudeness themselves.

The environs of the town were well explored, and the excursions to Quebec, Ottawa, Toronto, &c., filled to overflowing. Altogether the trip across the Atlantic was very enjoyable, and those who went have been amply repaid for their expenditure and trouble.

The character of the papers read has been above the average, but much disappointment has been experienced at the few contributions received from Canada and from the States. Doubtless the Americans were mindful of their own forthcoming meeting, and probably the Canadians were too busy with their preparations for welcoming and preparing for their guests.

It was scarcely an electricians' meeting. No striking facts of novelty were introduced, nor was there any paper of peculiar value or merit. Lord Rayleigh was the prominent figure of the meeting. The manner and matter of his remarks on all occasions were very impressive. The portion of his address dealing with electricity was very exhaustive and instructive. He gave four short papers, one describing an interesting lecture experiment on induction, the other describing a galvanometer he uses to measure powerful currents of electricity, the third describing some experiments made to verify Clark's cell, and the fourth a formula and calculation to determine the distance along a cable that it is possible to speak by telephone with a cable of the Atlantic type. The theoretic limit was about twenty miles. His formula was based on the influence of inductive capacity in lowering the intensity and the number of the vibrations per second. Professor Graham Bell was present during the discussion that followed the last paper, and Mr. Preece gave some experimental facts that tended to confirm Lord Rayleigh's deductions. He showed that the distance through which one could speak was a question of induction and not of resistance, and if a small wire were carried to the moon we should be able to speak, though the distance was 240,000 miles. The chief difficulty in working long distances was overcome by using metallic circuits, the two wires forming the circuit twisting around each other with a very long lay, so as to neutralise all disturbances from neighbouring wires.

Sir William Thomson was not so ubiquitous or communicative as usual. His duties as president confined him to Section A. He brought forward very few papers, and nothing electrical. Of course he took an active part in the discussion in his own section, and he patronised Section G on its electrical day. It is generally arranged to make Friday the electrical day in Section A and Monday in Section G. The most interesting feature of the meeting was the discussion in Section A, on the seat of electromotive force in the voltaic cell. This was experimental, and the experiment was so successful that this mode of dealing with questions of moment will probably now become annual. For instance, it has been suggested that next year shall be taken on standards of light. Professor Oliver Lodge opened the discussion with remarks which, though written, were so fresh, original, and interesting, that they were ordered to be printed *in extenso*, and we shall have the pleasure of giving them to our readers. The discussion, which, though well maintained, was all on one side. The supporters of the chemical theory were nowhere. If electricity flowed through the seat of electromotive force, energy was evolved or absorbed there, and wherever energy was absorbed or evolved there was the seat of electromotive force. This was the surface of the metal and acid, and the primary cause of the disturbance that lead to the production of currents was contact. Professors Fitzgerald, Silvanus Thompson, Willard Gibbs, Schuster, and MacAlister, and of course Sir William Thomson, took part in the discussion.

In Section B there was an extremely interesting discussion on the constitution of elementary bodies, which was led off by Professor Dewar, who maintained the atomic theory now so universal, and narrated the present condition of our knowledge on this point. Is the atom decomposable, as is the molecule? What is the difference between an elementary and a compound body? It is a question of syndethes, says Professor Dewar. Oxygen is $O + O$, and is therefore a molecule, and not an atom. Peroxide of manganese and peroxide of hydrogen mixed give out oxygen in those molecules. CH_3 in simple molecules is methyl, but $2(CH_3)$ makes a different molecule, and a different substance called ethyl. Professors Frankland, Lyon Playfair, Walcot Gibbs, Gladstone, Roscoe, and Liveing, took part in the discussion, which was very well maintained.

A second discussion took place in Section A, inaugurated by Professor Schuster, on the connection between sun-spots and terrestrial phenomena. There was no difference of opinion as to the connection between the phenomena of terrestrial magnetism, auroras, and earth currents with disturbances in the sun, but doubts were expressed as to any connection with rainfall, famines, and other abnormal phenomena. The discussion was not so well maintained as on the other subjects, for it did not involve so much a question of personal opinion or individual theorising as it did a comparison of facts. Professors Perry (of Stonyhurst), Douglas Archibald, and Lant Carpenter were the only speakers.

Mr. Preece's communications were four—one in Section A on the Law Determining the Connection between Current and Light Emitted in the Incandescent Filaments of Glow Lamps. He pointed out that the light emitted from an incandescent carbon filament varied as the sixth power of the current, but that this law was followed only between the limits embracing the ordinary range of a glow lamp when used for artificial illumination. At the point where the law commenced to be departed from disintegration probably commenced, and this point ought to be determined for all lamps, so that their state of incandescence might be limited. His second paper, read in Section G, dealt with the watt, which he desires to be legalised like the ohm and ampere; and he suggested that the horse-power should be increased in value 34 per cent., so as to make it equivalent to 1,000 watts and to bring it into the C.-G.-S. system of absolute measurement. The third paper dealt with some experiments with secondary batteries for telegraphic purposes, and the fourth paper was on Domestic Electric Lighting, in which he described the fitting up of his own house.

The sole electrical paper of Sir William Thomson was on Safety Fuses for Electric Circuits, which he considered highly essential, but he objected to the use of lead and other soft metals. He used fine copper wire about ¾in. long.

Professor Frankland gave an interesting paper on Secondary Batteries, the results of his own long-continued experiments. He divides the discharge into two portions, one of which he calls the useful, and the other the useless electricity, and these are due to two distinct chemical changes. The paper was read in Section B. It was beyond the chemists, and was not, therefore, much discussed.

Electrical tramways, and the transmission of power, were brought forward by Dr. Traill and Mr. Holroyd Smith. The former gentleman illustrated his paper by an admirable working model that was manipulated by Professor Fitzgerald. Dr. Traill said that the working expenses are about one-fourth those of horse-power.

Professor George Forbes read a paper on the Heating of Conductors by Electric Currents, reiterating the views given by him before the Society of Telegraph Engineers last session, and Professor Silvanus Thompson discussed ~~Some Points~~ in Dynamo-electrical Machines, with special reference to the

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direction of the leads of the brushes on the commutator. His views on dynamos are well known from his papers read before the Society of Arts. They are also published in book form by Messrs. Spon.

In Section A, Professor Fitzgerald gave an interesting paper on the analogy between electricity and heat, and Professors Reinold and Rucker one on the Thinning of Liquid Films by Electric Currents, in which they showed that a coloured film of a soap solution turned black, becoming about half its former thickness, when an electric current was passed through it, returning to its original colour when the current ceased.

Professor Oliver Lodge threw out a curious suggestion in his lecture on "Dust," which was to utilise the steam-power on board our ocean steamships to work large Holtz machines, so as to discharge copious sparks from the mastheads to dissipate fogs. He showed on a small scale how this could be done.

The meetings of the sections were unusually well attended, and both Canadians and Americans showed a lively interest in the way in which business was conducted. The Americans seemed to reserve their forces for their own meeting in Philadelphia. They did not often take part in the discussions, but when they did they spoke with force and power. Professors Willard Gibbs and Newcomb came most to the front, though Professors Rowland, Barker, Canhart, and others carried on with great spirit that friendly intimacy and contact that makes science such a true republic.

The meeting will not be memorable for any novelty, but it will never be forgotten as a gigantic experiment and a very pleasant outing.

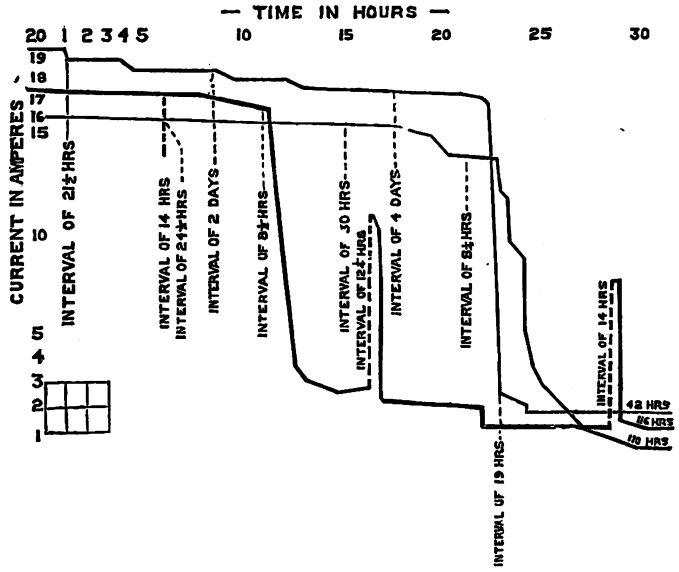
The death of Mr. Walter R. Browne, the late secretary of the Mechanical Engineers, was a sad event that marred the pleasure of many, for he had many friends in Montreal.

On the Discharge of Electrical Accumulators.*

BY E. FRANKLAND, F.R.S.

In a communication to the Royal Society on this subject (*Proc. Roy. Soc.*, Vol. XXXV., p. 67) I described certain experiments which went to prove that the active material in an uncharged accumulator (in which, when charged, spongy lead and lead peroxide are the opposing plates) is lead sulphate; that, in charging, this lead sulphate is decomposed on the positive electrode, the formation in both cases of hexabastic sulphuric acid, and that in the discharge these chemical changes are reversed, lead sulphate being reproduced on both electrodes and plates. These results are in the main confirmatory of previous experiments made by Gladstone and Tribe. I also stated that the sulphuric acid thus added to or withdrawn from the liquid contents of the cell can be made to indicate by change in specific gravity the degree of charge in the cell at any given moment. At the conclusion of the paper I expressed a hope that further experiments would enable me to denote in terms of current from the cell the definite relation between the amount of energy stored and the weight of sulphuric acid liberated. I have not as yet, however, obtained results which would justify me in announcing this equivalent, but I venture to think that the details of some experiments which I have made with this object may not be altogether uninteresting at a moment when the storage of energy is attracting so much attention.

The storage cell employed contained ten plates, each having two active surfaces of 11in. by 9in. Rejecting the free sides of the two endmost plates, the total effective surface was 12·3 sq. ft. These plates were completely immersed in dilute sulphuric acid, of which the cell contained about 14 imperial pints. The cell was fully charged in series with several others by a current from a Siemens shunt machine, varying usually from 15 to 20 amperes, and it was then allowed to rest for three days. The discharge was made through a piece of platinum wire, 1·035 mm. in diameter and about 10in. long. Carefully sheltered from drafts, this wire was maintained at a red heat just visible in the dark so long as the current did not sink below 17 amperes. The current was measured by a Siemens electro-dynamometer constantly included in the circuit. As the complete discharge occupied 73 hours, it had to be frequently interrupted. These interruptions are not mentioned in the following tabulated results, but they are noted in the accompanying diagram, which shows these results in the form of a curve. The current maintained itself at between 19·61 and 18·09 amperes for nearly 22 hours, and then fell very suddenly in the course of about an hour to less than three amperes, at which rate it continued for upwards of 50 hours. At the end of this time the current was still 2·57 amperes, when it was stopped at 10:30 p.m. At 6:30 the



following morning, on re-establishing the circuit, no perceptible current passed.

The following are the tabulated results of the discharge :—

Date. April.	Duration of discharge. H.	M.	Currents in amperes.	Ampere hours.
7	1	0	19·61	19·61
8	2	30	19·24	48·11
8	5	6	18·81	95·98
10	3	0	18·61	55·88
10	0	45	18·37	18·78
10	4	38	18·28	84·39
10	4	15	18·23	77·48
10	0	30	18·09	9·05
10	0	8	17·77	2·37
10	0	18	15·37	4·61
10	0	12	9·45	1·89
10	0	9	5·42	·75
10	0	23	3·67	1·41
15	1	14	2·87	3·54
15	6	50	2·78	18·65
15	2	55	2·41	7·03
16	2	15	2·78	6·14
16	0	45	2·65	1·99
16	1	55	2·57	4·98
17	5	10	2·57	13·28
17	2	20	2·49	5·81
17	1	5	2·41	2·61
18	15	50	2·57	40·69
19	1	15	2·78	3·41
19	3	15	2·57	8·35
20	2	22	2·78	6·46
20	3	0	2·57	7·71
	73	5		545·81

The cell therefore kept up a current for 73h. 5m., and delivered an aggregate charge of 545·81 ampere hours. Of this charge 404·18 ampere hours were delivered with an electromotive force of about two volts, whilst 141·63 ampere

* A paper read before the British Association at Montreal.

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hours were delivered with an E.M.F. of only about three volts. This result may be tabulated as follows:—

	Ampere hours.
Useful electricity or electricity of high E.M.F. (two volts or upwards)	404·18
Useless electricity of low E.M.F.	141·63
	545·81

In the experiment just described the discharge at high electromotive forces was rapid, but the cell had many intervals of rest, several of them long ones. Thus, after the first hour's discharge at the rate of 19·61 amperes, there was a rest of 21½ hours. Then the discharge was continued at the rate of about 19 amperes for 7 hours 36 minutes, followed by a rest of two days, when the discharge was maintained at nearly the same rate through the same resistance for 8 hours 23 minutes. Then came another rest of four days, at the end of which time the discharge started at exactly the same rate as that at which it had previously left off, and continued at very nearly the same rate for 4 hours 45 minutes longer, when it suddenly fell off to about 2¾ amperes.

In the next experiment, which was made with a cell similar in all respects, the heavy current was taken continuously up and down the fall, with the exception of one break of fourteen hours at the end of six hours. The following are the numbers noted during the discharge:—

Date. June.	Duration of discharge. H.	M.	Currents in amperes.	Ampere hours.
9	6	5	17·47	106·23
10	1	40	17·47	29·11
10	1	60	17·15	31·44
10	1	40	16·50	27·50
10	1	15	4·06	5·07
10	0	35	3·62	2·05
10	1	30	3·15	4·72
10	2	5	3·28	6·83
11	0	5	11·69	97
11	0	12	11·33	2·27
11	0	6	9·54	95
11	5	0	2·37	14·35
11	6	20	1·82	11·53
12	0	5	9·10	76
12	0	5	6·42	54
12	0	5	4·06	34
12	0	5	2·57	21
12	1	40	2·03	3·38
12, 13	36	20	1·82	66·13
14	10	40	1·32	19·41
Here current of 22·15 was passed through cell for 1 hour, and intervals of 3 hours allowed before continuing discharge.				
14	0	3	9·96	50
14	0	7	8·03	95
14	0	10	4·06	68
14	0	30	3·70	1·35
14	0	10	2·87	48
14	0	10	2·57	43
14	1	20	2·41	3·21
14	0	25	2·03	35
14	6	35	1·82	11·98
15	24	0	1·82	43·68
16	20	0	1·82	36·40
16	2	0	1·58	3·16
17	0	1	2·87	·05
17	0	1	2·08	·03
17	0	3	1·82	·09
17	0	50	1·58	1·32
17	12	20	1·29	15·91
18	0	1	2·41	·04
18	0	15	1·58	·39
18	0	45	1·29	·97
18	0	30	·91	·45
	147	39		457·26

The current maintained a nearly uniform rate of between 16½ and 17½ amperes for eleven and a quarter hours, or only for about one half the time in the previous experiment. It then suddenly sank to little more than 3 amperes, but rose again for a few minutes to over 11 amperes after a rest of twelve hours. It then sank to 3 amperes, and finally to less than 2, after nearly twelve hours continuous discharge; but after fourteen hours' rest it again rose for a few minutes to nearly 10 amperes, to sink in fifteen minutes to 2·57, and in another hour and forty minutes to 1·82 ampere, at which rate it remained for forty-seven hours continuously.

Under perfectly constant conditions of discharge it was interesting to try the effect of interpolating a fresh charge from the dynamo. Accordingly the discharge was interrupted, and immediately a steady current of 22·16 amperes was sent through the cell for exactly one hour, and the cell was then allowed to rest for three hours. On recommencing the discharge through the same resistance as before, a current of 9·96 amperes was obtained; but this was maintained for three minutes only, and at the end of an hour it had sunk to 2·87 amperes. It was only, however, after the lapse of eight hours that the rate of 1·82 ampere was resumed, and this was afterwards continuously maintained for fifty-two hours. Thus, of the twenty-two ampere hours with an E.M.F. of about 25 volts put into the cell, only 8·94 ampere hours came out again with a higher E.M.F. than that possessed by the previously constant current of 1·82 ampere. Moreover, the E.M.F. of the augmented current never exceeded 1·09 volt, whilst in 20 minutes it sank to ·49 volt. This result shows how wasteful it is to keep a storage cell in circuit after the high E.M.F. portion of its charge has been extracted. Altogether the complete discharge of this cell occupied 147 hours 39 minutes, and there was obtained:—

	Ampere hr.
Useful electricity or electricity of high E.M.F. (two volts or upwards)	194·38
Useless electricity or electricity of low E.M.F. omitting the 22·15 amperes hr. interpolated	240·78
Total......................	435·11

The cell, therefore, contained a smaller aggregate charge than the previous one, but what is of much more importance the proportion of useful electricity was greatly diminished, for whilst, in the first experiment, the proportion of useful or useless electricity was 5:7::2, in the second it was only 1:6::2. It can scarcely be doubted that this diminished proportion was due to the much more continuous nature of the discharge in the second case.

In order to test this conclusion, however, a third cell was submitted to experiment. This cell contained 13 pints of diluted acid, but only eight plates 8·5in. × 11in., or an aggregate effective surface of only 9·09 square feet, as compared with 12·3 square feet in each of the former cells. On this account the cell was discharged through a somewhat higher resistance, so as to obtain a lower rate of discharge.

Duration of Discharge. H.	M.	Current in amperes.	Ampere hours.
9	45	16·2	157·9
6	35	15·8	104·0
2	45	15·5	42·2
1	0	14·8	14·8
2	20	14·7	34·3
	15	13·2	3·3
	20	12·8	4·3
	15	10·9	2·7
	25	10·4	4·3
	25	9·9	4·1
	15	6·6	1·65
	25	4·6	1·91
	20	3·75	1·25
	25	3·28	1·36
1	0	2·57	2·57
	50	1·82	1·52
2	30	1·29	3·22
111	30	91	101·46
141	20		486·84

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The cell maintained a nearly uniform current, averaging 15·8 amperes for almost the same time (22 hours) as the first cell. The current then sank, not quite so suddenly, to 91 amperes, at which rate it continued steadily for 111½ hours. During the course of this discharge the cell had the following period of rest:—Discharge, 6h. 5m.; *rest*, 25h. 35m.; discharge, 5h.; *rest*, 8h. 30m.; discharge, 4h. 20m.; *rest*, 6h. 10m.; discharge, 4h. 40m.; *rest*, 8h. 15m.; discharge, 121h. 15m.

These periods of repose had a most beneficial effect on the economic value of the charge. For whilst the cell, discharged with but little rest, gave a proportion of useful to useless electricity of only 1 : 6 : : 2, this cell, with intermittent discharge, yielded a result expressed by the proportion 6 : 5 : : 1, which is even higher than that obtained from the cell used in the first experiment. The complete discharge of this cell occupied (exclusive of the periods of rest) 141 hours 20 minutes, and there were obtained:—Useful electricity, 371·9 amperes; useless electricity, 114·9 amperes—total, 486·8 amperes.

In all these experiments moderate currents only were drawn from the cells, such as would be used for the supply for 14 or 15 Swan lamps of 20 candle-power; but much heavier currents can be obtained if desired, for Messrs. R. E. Crompton inform me that they have obtained from a cell of 12 plates of the same construction a steady current of 250 amperes. It would thus be possible, by coupling in parallel only 30 such cells, to obtain for a short time a steady current of no less than 7,500 amperes. The results of these experiments permit the following conclusions to be drawn:—

1. The energy of a charged storage cell is delivered in two separate portions, one having an E.M.F. of 2 volts and upwards, the other an E.M.F. of 5 volts or under; one of these may be termed useful electricity, the other useless electricity.

2. The proportion of useful electricity obtainable is greatest when the cell is discharged intermittently and least when the discharge is continuous.

3. Neither in the intermittent nor continuous discharge at high E.M.F. is the current, through uniform resistance, augmented by rest. At low E.M.F., however, the current, after continuous discharge of the high E.M.F. is greatly augmented, but only for a few minutes. This augmentation of current at low E.M.F. after rest is barely perceptible when the high E.M.F. discharge has been taken intermittently.

4. The suddenness of fall in potential indicates two entirely distinct chemical changes, the one resulting in an E.M.F. of about 2·5 volts, the other in one of eight volts.

5. The chemical change producing low E.M.F. is the first to occur in charging, and the last to take place in discharging a cell. It is the change which occurs during what is called the formation of a cell, and in the interest of economy, a reversal of this change should never be allowed to take place.

6. It would be difficult to suggest an explanation of the nature of these two chemical changes; but I refrain pending their actual investigation in which I am now engaged.

7. Currents of enormous strength may be obtained from storage batteries coupled up in parallel. For instance, a current of 25,000 amperes is quite feasible from only 100 cells. Such a current reduces to insignificance the output of the largest dynamo ever built. It is to be hoped that currents of this magnitude will open up new possibilities of research into the constitution of matter.

The Watt and Horse-power.*

BY W. H. PREECE, F.R.S.

The most practical unit in use among electricians that has been derived from the C.-G.-S. system of absolute measurement is probably the watt, or the rate of doing work when a current of one ampere is maintained through a resistance of one ohm. The work done by an electric current is thus brought into intimate relation with all other kinds of work. The common gravitation unit rate of working is the horse-power, which is 550 foot-pounds per second. The absolute C.-G.-S. unit is the erg per second, or the work done in one second in overcoming the force of one dyne through a distance of one centimetre. In any electrical measurement the electromotive force (E) in volts multiplied by the current (C) in amperes gives a product (E C) equivalent to so many 10^7 ergs per second, which is the watt. There are 746 watts in a horse-power, and E C is reduced to horse-power by dividing it by 746. The rate at which electrical energy is developed or expended in any part of any circuit is given in watts when we multiply by the number of volts by the number of amperes. Strange mistakes are made in confusing the unit of power with the unit of work. No less an authority than Professor Adams, in his inaugural address as president of the Telegraph Engineers and Electricians, spoke of the watt as the unit of work, and gave its value in kilogrammetres as kilogrammetres = watts × 10192. It is evident that as the watt is the unit of power it is equal to 10192 kilogrammetres per second, or, in other words, work done at the rate of a kilogrammetre per second = 981 watts = g watts.

I cannot help thinking that the good work of the British Association Committee will not be complete until the C.-G.-S. system is authoritatively applied to work and power. The following table brings together nearly, if not all, the units in common use:—

Unit.		Equivalent.
Horse-power	33,000	foot-pounds per minute.
,, ...	550	foot-pounds per second.
,, ...	746	× 10^7 ergs per second.
,, ...	7460	megergs per second.
,, ...	75·9	kilogrammetres per second.
,, ...	1·01385	force de cheval.
,, ...	746	watts.
Force de cheval............	75	kilogrammetres per second.
,, ...	542·48	foot-pounds.
,, ...	0·9863	horse-power.
,, ...	736	watts.
Watt	·0013405	horse-power.
,, ...	10^7	ergs.
,, ...	10	megergs.
,, ...	$\frac{1}{9·81}$	kilogrammetres per second.
,, ...	·1029	kilogrammetres per second.
B. of T. unit	1000	watts per hour.
C.-G.-S. unit...............	erg	per second.
Megerg	10^6	ergs per second.
Watt	10^7	ergs per second.

According to Professor Dewar a standard sperm candle develops 240,000 foot-pounds per hour, or 4,000 foot-pounds per minute. Now, since a watt is equivalent to 44·2 foot-pounds per minute, it follows that a standard candle develops 90 watts per minute. Again, according to the same authority, 5 cubic feet of coal gas in London develops 2,500,000 foot-pounds per hour, or 4,666 foot-pounds per minute, or 2,976 foot-pounds per candle per minute, which is equivalent to 67 watts per minute. A good glow lamp absorbs 2·5 watts per candle per minute; hence a glow lamp has an economy in energy of about 1-30th of a gas lamp and 1-40th of a standard sperm candle. A man working very hard expends about 100 watts per minute, and if a man-power is equal to, say, one standard candle, it is equal to 1·34 gas candles and 36 electric candles. What a field for economy in lighting, and how essential it is that gas should be applied to the production of power rather than to the production of light.

The horse-power as a unit has all the defects of an arbitrary unscientific standard. It involves the use of coefficients, and it is not connected directly with the absolute system of measurement. It differs in different parts of the world, and its name is misleading. It could be changed both in value and name without any inconvenience, except to those who are too familiar with the existing coefficients and formulæ. If its value were raised 34 per cent. it would become the kilowatt, and be connected directly with the C.-G.-S. system. It would thus become a scientific system, and diminish the use of coefficients. Even the present name could be retained, and its value altered from 746 to 1,000 watts, or from 33,000 foot-pounds to 44,233 foot-pounds per minute without any serious inconvenience. Existing numbers expressing horse-power would simply have to be multiplied by 746 to bring them to the value of the new unit, or numbers in the new unit would have to be multiplied by 1·34 to express their value in the old system.

I cannot help thinking that the good work of the B.A. Committee will not be complete until the C.-G.-S. system is authoritatively applied to work and power.

* A paper read before the British Association at Montreal.

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THE ELECTRICIAN.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

ANSWER TO CORRESPONDENT.

G. A. G.—*The note you refer to was not unnoticed by us, but it is hardly in our province to indicate all such matters. You will see by other news that such things "cut two ways."*

CONTENTS.

Notes ... 465
British Association:—
On the Discharge of Electrical Accumulators. By E. Frankland. Illustrated ... 471
The Watt and Horse-power. By W. H. Preece ... 473
The Electric Light at Colchester ... 474
Correspondence ... 475
The Philadelphia Exhibition. II. Illustrated ... 475
Philadelphia Electrical Congress ... 477
On a Standard Tangent Galvanometer. By Professor S. P. Thompson ... 478
Variations in the Physical Properties of Bismuth in a Magnetic Field. By M. Hurion 479
Electric Light Installation in the Leipziger-Strasse and Potsdamer Platze, Berlin ... 479
Fatal Accident from a Dynamo at the Health Exhibition ... 480
Professor Rowland's Presidential Address at the Philadelphia Congress ... 481
Companies' Meetings—
Direct Spanish Telegraph Company ... 483
Great Western Electric Light and Power Company ... 484
Companies' Share List ... 484

THE ELECTRIC LIGHT AT COLCHESTER.

The vestry of the parish of Chelsea is to be congratulated on having for its surveyor a gentleman who is at once free from the prejudices of his profession, cautious enough to guard his clients from going too fast, yet sufficiently alert to insure them against the reproach of being too slow. We have on one or two former occasions commented upon Mr. G. H. Stayton's reports relating to electric lighting, and we have before us now, dealing exclusively with the installation at Colchester, a document in which the brevity and directness of his remarks are as conspicuous as ever. At the conclusion of his paper, after a personal visit to that town, and a careful inspection of what has been done there in the interval between June last and the present time, he expresses his opinion that the time has now arrived when the question might be considered by the Chelsea Electric Lighting Committee for their report upon the desirability or otherwise of taking any steps under the powers of The Electric Lighting Act, with a view to the introduction of electricity for the purposes of illumination in that parish. Mr. Stayton's report, we understand, has been accordingly referred to the committee, and in due course we may expect to hear their decision.

Now, without in the least attempting to influence the deliberations of this committee, much less to predict what their recommendations may be, we feel ourselves at liberty to express a general satisfaction with the Chelsea surveyor's report. From correspondence which has appeared in our columns, and from other sources of information, we have not been free from misgivings as to the character of the work, or the system employed in carrying out the Colchester installation; and even after a perusal of Mr. Stayton's report we are by no means sure that the best has been done that might have been practicable under more favourable circumstances and a greater amount of capital expenditure. We are, perhaps, not disinclined to endorse the opinion of an unfriendly criticism in the *Journal of Gas Lighting* of last Tuesday, the writer of which is "struck with the paltry practical outcome of a movement that has commanded millions of capital;" for, at the first glance, it does seem disheartening that of all the big schemes that have been floated the one that has contrived to avoid partial or complete submersion is an obscure company, in a comparatively insignificant locality, provided with very inadequate means. But, on the whole, these disadvantageous conditions speak well for the general results, which Mr. Stayton assures us have given great satisfaction on the spot. The gas journal just quoted asserts that a large hotel in Colchester has withdrawn its custom; a statement which is not confirmed in the Chelsea surveyor's report, and which in any case is not explained, and may therefore, even if it is true, be accounted for by reasons other than dissatisfaction with the light itself, or the price demanded for its use.

As regards the price, Mr. Stayton frankly admits that it is, light for light as compared with gas, 33 per cent. dearer; and that thus it may be regarded as a luxury. But he is not so precise as we could have wished in respect to the illuminating power of the electric lamps; in other words, as to the number of lamps required in place of the gas burners giving an equivalent amount of light. In one portion of his report, indeed, we notice that the necessity for outside gas lamps with reflectors has been done away with by the introduction of electric lights inside the shop windows; and if this is generally the case a considerable saving of argand gas burning must have been effected. Such comparisons of price, like similar comparisons of light, are, as we have over and over again pointed out, altogether untrustworthy; the only comparison the customer will care about is between the bills he formerly paid and those he has now to pay for lighting his premises in an effective way. But should the balance at Colchester turn in favour of gas, there is still apparently a large margin left for reduction to the consumers, the profit of the 14½ per cent. which the managing director states he would realise if his customers were appreciably increased being larger probably than the company would think it expedient to continue demanding. It is to the interests of the inhabitants of Colchester, therefore, to encourage the extension of the electric light throughout the assigned area; and if, as is alleged, the advantages of the light are greatly appreciated by the present users, there is reason to hope that the demand for it will greatly increase. Meanwhile, as a matter of business, we should advise the adoption of rates as low as possible, based on the well-founded assumption that the area of demand will be covered in due time so as to yield a good profit.

One of the chief merits of the electric light for shop interiors is dwelt upon in Mr. Stayton's report with an emphasis it well deserves. Not only is the contrast between shops illuminated by gas and those where electricity alone is employed extremely unfavourable to the former in general splendour of effect, but the colours of the goods show up with perfect truthfulness, and their texture is not affected by heat or noxious fumes. This, to our thinking, is a most important feature of the electric light. The *Journal of Gas Lighting* makes fun of somebody who has mistaken Lewis's incandescent gas burners for incandescent electric lamps, and reported that the air of Gower-street Railway Station is greatly purified by their use. But the

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mistake is only laughable if the air is really no purer; that is the main question, and it is one which the gas interest has taken very little pains to solve. Meanwhile, we are justified in asserting that the electric lamp is the only pure and harmless light in existence; and if the damage done to the shopkeeper's material goods, to say nothing of his human assistants, by the use of gas is set against the perfect immunity from this source of deterioration when electricity is employed, the difference in actual cost will not be so great as it seems. In a large number of instances, we are persuaded, the electric light might supersede gas with profit, even if their respective prices differed more than they do. This fact is better known probably in London than it is in Colchester, and should the effect of Mr. Stayton's report be to induce the Chelsea Vestry to give London a trial on a larger scale and under better auspices than the experiment at Colchester has enjoyed, we entertain no doubt that it would be a commercial success as well as a great social boon. Some of the vestrymen object to the employment for this purpose of capital obtained from the ratepayers' pockets. We can sympathise with the objectors, and hope they may see their way to the employment of private enterprise independent of the now discredited Electric Lighting Act.

CORRESPONDENCE.

SPEED OF THE WHEATSTONE INSTRUMENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to the question of "X," in *The Electrician* of 27th inst., I would observe that the speed mentioned for the Wheatstone in the *Formulaire Pratique de l'Electrician* refers to a line of from 600 to 700 kilometres (372 to 435 miles) long. If "X" will refer to a passage a few lines higher up, he will see that, *on a short line*, the Wheatstone is capable of transmitting as many as 130 words a minute. Moreover, these figures agree with those given by Messrs. Preece and Sivewright in their "Text Book on Telegraphy," second edition, sections 126 and 127.—Yours, &c.,

Paris, 29th September, 1884. E. HOSPITALIER.

INTERNATIONAL EXHIBITION OF INVENTIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The International Exhibition of Inventions, 1885, will bring together the inventors and patentees of all nations, and an opportunity will be afforded, which will not again occur for many years, of developing an international patent law.

The International Convention for the Protection of Industrial Property, which by an Order in Council came into effect on the 7th July last, has not been signed by Germany, Russia, Austria, or America. These countries therefore were, for different reasons, not satisfied with the terms of the convention. All our attempts at patent-law legislation, whether international or on our own account, have proved failures for the same reason, namely, because the actual requirements of inventors have not been ascertained. The interests of inventors are identical with those of the public; encourage invention and you create trade.

One of our leading statesmen has said, "Inventors are the creators of trade." If this is so, on what possible principle can any tax whatever be levied on letters patent? Such a tax must of necessity hinder the "creation of trade," must throw obstacles in the way of development of new inventions, must deprive the Treasury of large sums which would flow into it in the way of income-tax, and, worst of all, must deprive the operatives of this country of numerous sources of employment. If inventors as a body could only realise the extent of their numbers, the talent, influence, and even wealth of their individual members, they would lose no time in exerting such a combined and irresistible pressure on the Government as would result in a complete revision of the Patent Laws, and would lead to a revival of the trade of the country. —Yours, &c., H. P. DEANE, Secretary.

Inventors' Institute, 27, Chancery-lane,
29th September, 1884.

DIMENSIONS OF DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am making a Schukert dynamo for incandescent lighting, and should feel much obliged if you could give me information through the medium of your paper as to the wire I ought to use to make it shunt wound, and to give an E.M.F. of 100 volts.

The dimensions (unwound) are:—External diameter of armature, 6in.; internal diameter of armature, 3in.; thickness of armature, ½in.; number of sections, 16; length of magnet cores, 2½in.; diameter of magnet cores, ⅞in.

Will you inform me:—1st. Length and B.W.G. of wire on each of the four magnet cores; 2nd. Length and B.W.G. of wire on each section of armature.

The dimensions are one quarter those of a four-arc light machine, so that I ought to be able to light 10 sixteen candle-power lamps.—Yours, &c., F. J. SHAW.

7, Stanton-villas, New Southgate.
October 1, 1884.

NON-MAGNETISABLE WATCHES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Mr. Grundy's letter in your last issue, I write to say that it is not necessary to go to America to obtain non-magnetisable watches, as I have made them since 1880. They were exhibited at the Electrical Exhibition at the Crystal Palace in 1882, and were awarded a medal.—Yours, &c.,

5, Queen Victoria-street, E.C., R. WEBSTER.
29th September, 1884.

DUNDEE TELEPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should feel much obliged if any of your correspondents would give me any information *re* the Dundee Telephone Company, such as the system used, number of subscribers to the exchange, number of private renters, mileage of wire used, &c. I hear that the subscription is only £5 per annum; if so, please state, and oblige—Yours, &c.,

CURIOSITY.

29th September, 1884.

THE PHILADELPHIA EXHIBITION.—II.

(FROM OUR SPECIAL CORRESPONDENT.)

PHILADELPHIA, SEPT. 19.

This week has witnessed a great improvement in the Electrical Exhibition. The exhibits are all in order, the lights are all ablaze, and the hall is crowded nightly. Many additions have been made to the exhibits, among them an electric railway car running on a short track. This, although a very bad sample in itself, serves to complete the exhibits of practical applications of electricity. The Conference having adjourned, a course of lectures on electrical subjects is being delivered in the annexe to the Exhibition hall. They attract large audiences, the lecturers being famous professors (here on other business), and the Exhibition affording them a great wealth of illustrative apparatus.

One of the chief objects of curiosity for the last few days is a nameless piece of apparatus in the Edison exhibit. All the electricians have examined it, and countless theories have been offered to explain the observed phenomena, but none are wholly satisfactory. Fortunately the apparatus is so simple as to be easily described and readily understood. An ordinary Edison lamp has introduced within the loop a small ribbon of platinum. This is in no

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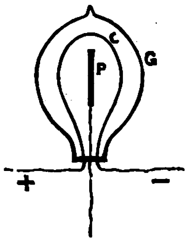
place nearer to the loop than, say, a quarter of an inch, and terminates about that distance from the turn of the loop. It is connected with a separate conductor, carried out to a binding post, and is sealed in the glass like the other conducting wires. The bulb is exhausted of air, so as to produce as high a vacuum as possible. For experimental purposes a resistance box is put in the circuit to regulate the current. Let us suppose a conductor to be led from the positive pole of the lamp filament to a galvanometer, the other conductor from the galvanometer being carried to the central strip of platinum which terminates in the vacuum. The galvanometer stands at zero. On turning on the current through the carbon filament the deflection of the galvanometer shows that a current is also passing through the strip of platinum, or, in other words, that the circuit is completed in some way through the vacuum. As the lamp is raised to a higher degree of incandescence the deflection becomes greater, the action being precisely the same as though the circuit including the galvanometer was metallic throughout. This, it must be remembered, is while the positive pole of the lamp is connected with the galvanometer, and the deflection generally reaches about 75 or 80 degrees. The current is, in fact, sufficiently powerful to work a telegraphic relay, which is sometimes put in circuit in place of the galva nometer. This in itself is a pretty hard nut to crack, but the phenomenon that upsets most of the theories brought to explain the action is observed when connection is made with the negative instead of the positive pole. The needle ought then apparently to be deflected in the opposite direction, and it is, but only to the amount of a single degree or a fraction thereof. All other known conditions being precisely the same, the deflection when the positive pole is in the galvanometer circuit is, say, 75 degrees, while with the negative pole it is only half a degree the other way. Edison does not explain the observed facts, he merely presents them, but he says that the apparatus may some day be the germ of a new theory of electrical action.



He has another very curious apparatus with an incomplete circuit, if there can be such a thing. For want of something else by which to call it, the attendants say that it is devised to make visible the "etheric force." A conductor is carried through a closed box under a microscope. In the field of the microscope there are two carbon points forming part of the conductor, and (I presume) presenting a point of imperfect contact.

One end of the conductor outside the microscope is connected with an automatic current breaker, the other end is carried to an insulated support; in other words, there is no circuit formed. Nevertheless, upon turning on the current the carbon points under the microscope are seen to glow. The most delicate testing apparatus fails to show the presence of electricity, but some form of energy is evidently at work in the conductor. This description of the apparatus and its effects I derive from one of the attendants, having had no opportunity to examine it. No explanation of the phenomena is offered.

The passage of the current through vacuo in the manner described above I examined for some time. The galvanometer deflection remained constant while I was looking at it, but I am told that it is sometimes subject to erratic changes, and that while connection is made through the positive pole and without any known alteration of the conditions, the needle has returned to zero, then deflected in the reverse direction, returned to zero, and deflected again to the right without any observed cause, acting very much, however, as though relieved of a static charge and again charged. Edison says that some one once had a theory that a high vacuum was as good a conductor of electricity as copper wire, but that he never succeeded in proving it. This apparatus might help him but for the strange want of apparent conductivity through the negative pole. For the present these curiosities (of no practical use so far as known) attract more attention from the electricians than anything in the Exhibition.

Another curiosity is the Sprague motor, which is remarkable in its performances, and attracts special attention, because the inventor, not having yet secured his patents, declines to explain its action. One of the machines is used for running a loom, which requires to be kept at perfectly constant speed, and to be subject to instant stoppage at the will of the workman. A speed indicator attached to the motor shows that the purpose is attained. It was running when I saw it at 360 revolutions a minute. The indicator hand remained fixed at this point while the loom was running, and when it was stopped or started did not vary more than from five to ten revolutions before settling down to the standard fixed for it. The machine is also under very perfect control by hand, a device which fits it for locomotive service. It can be started slowly, the speed gradually increased, or slowed down, and the action reversed at will. This is undoubtedly done through changes in the strength and in the intensity of the magnet, but exactly how is the inventor's secret. The machine, however, is so plainly effective in doing what is wanted that it has won high commendation. At present the motors are run by the Edison current of about 100 volts, but they can be built for use with currents of any intensity, and the inventor prefers those of high electromotive force.

A strange incandescent lamp is shown by an electrician named Diehl, of Elizabeth, N.J., but he has unfortunately been unable to light it up, his machinery not being ready. The conductors do not extend beyond the glass enclosing bulb, and the current acts by induction. The carbon filament terminates in a coil of fine wire enclosed in a prolongation of the bulb, and is entirely surrounded by glass. In the middle of this coil, separated therefrom by the glass, the terminal of the conducting wire is formed into another coil with iron core. An alternating current is used, which acts by induction on the coil within the lamp, and so produces incandescence of the carbon filament. The lamp presents no apparent advantages in the way of manufacture, and is probably too costly for competition with other and more direct forms of conveying the current through the filament.

The Electrical Conference had long sessions during the two days following the writing of my last letter and then adjourned. In a discussion on the electrical transmission of energy, Professor Nipher said that he was engaged in attempting to represent graphically the energy transmitted by a dynamo generator and converted back to power by a motor. He hoped from his experiments to determine constants of a particular form of machine, which could afterwards be used as a standard of comparison with other machines. Professor E. J. Houston (Thompson-Houston system) thought that a standard for the transmission of energy could best be studied by the light which that energy was capable of producing. Mr. Sprague (the exhibitor of a motor above mentioned) did not agree with this opinion, and said that for effectiveness in transmitting energy it would be found necessary to use currents of much higher potential than any heretofore employed.

The discussion on storage batteries did not develop much that was new, but every speaker seemed to be disappointed with them except as adjuncts to lighting systems where the power was more or less intermittent. It was suggested that carbon be used for the plates of storage batteries, but it was generally believed that they would disintegrate rapidly. Professor Dewar, of Cambridge, thought that experiments ought to be made with a variety of other substances besides suboxide of lead, and suggested such salts as permangates, iodates, and hromates.

In discussing telephones, Mr. Lockwood, electrician for the Bell Telephone Company, expressed the opinion that the disturbing noises in the phones were generally due to atmospheric or terrestrial currents and seldom to induction from other lines. The conclusions he reached were against the use of underground conductors.

It should be explained perhaps that thousands of telephone wires are carried overhead in all our large cities, and that they have become such a nuisance that ordinances have been passed requiring their removal. The telephone companies, objecting to the expense of putting their wires underground, declare that this cannot be done.

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Mr. Preece combated some of Mr. Lockwood's conclusions, and gave interesting information (to Americans at least) about underground wires in English cities.

The conference during its session adopted resolutions asking the Government to undertake a series of observations of atmospheric electricity and the strength of earth currents. The methods recommended are those of the International Bureau of Telegraphic Administration at Berne, and it is proposed that the telegraph companies and private electricians shall co-operate with the officers of the signal service in making the observations.

Professor George Forbes opened the lecture course last evening by a lecture on the Theory of Dynamo Machines.

PHILADELPHIA ELECTRICAL CONGRESS.

The Conference assembled the fourth day in the Hall of the Franklin Institute, and was called to order by the President, Professor Rowland. The Committee on the Advisability of the Formation of a New Unit of Power reported verbally through Mr. W. H. Preece. The report called attention to the great necessity of some unit of power in accord with the metric system and with electrical engineering. This necessity the watt, in the opinion of the committee, met perfectly. A watt, defined electrically, was the rate at which work is done when a current of one ampere is maintained in a resistance of one ohm.

It has therefore been called the volt-ampere, but this name was awkward, and the name of Watt, himself the first careful measurer of power, was fitly appropriated to it by Professor Siemens. The unit of power which Watt adopted was the horse-power. By a series of experiments he determined the work of one horse to be about equivalent to that of raising 22,000 pounds one foot every minute. This number seeming too small to him, he added 50 per cent., and arbitrarily fixed the horse-power at 33,000 foot-pounds. As the watt is too small a measure to be suitable for large measurement, he proposed that the arbitrary horse-power be raised 34 per cent., so that, instead of representing 33,000, it would be about 44,000 foot-pounds. It would then be equivalent to exactly 1,000 watts. Mr. Preece moved that it is the opinion of the Conference that the unit of power should hereafter be the watt, and that the value of the horse-power should be raised so that it should equal 1,000 watts. After a little discussion the motion was adopted.

The Committee on the Standard Unit for Light reported informally through its chairman, Professor Trowbridge, that in the opinion of the committee the standard unit of light proposed by the Paris Conference was impracticable, and that they did not believe its adoption advisable in this country. He called upon one of his colleagues, Mr. Preece, who had prepared some statements.

[The standard unit of light here referred to is that amount of light of the same character as the light to be examined which is emitted from the surface of one square centimetre of melted platinum at the temperature of solidification.]

Mr. Preece said that he had devoted much time to the study of the measurement of light as a member of a committee of the British Association. Two points are necessary to be considered. First, the formation of a practical standard for all lights; and second, the accurate definition of the standard of white light. The first of these is practically all that is necessary to examine. After referring to the personal equation of the individual observer, he went on to consider the systems which are legal in the various countries. In England they have a standard sperm candle of certain quality and burning 120 grams per hour. In Germany they have a different standard candle. In France they use a lamp known as the Carcel, which represents about 9·7 of the British standard candle-power. Mr. Preece believed that all of these were defective, because they did not relate to the illuminating power, the important point of the light. He had proposed as a standard the light given off from a perfectly white surface when the light from a British standard candle fell upon it from a distance of 12·7 inches. This would correspond to the amount of light given off when the same surface was illuminated by a Carcel lamp at the distance of one metre. He thought the practical method of comparing and studying the three points, the standard of light, the standard of illumination, and the means of photometric measurements were best found in the incandescent electric lamp. It was convenient and accurate, and could always be reproduced. He promised further aid to the committee until their report to the commission should be rendered.

Professor Koyle asked if the surface of incandescent platinum of a certain size would not be better than that of the carbon filament. Mr. Preece replied that in the air the surface of platinum had not been successful, and that sufficient experiments had not been conducted with platinum in vacuo.

Professor Henry A. Rowland, of the Johns Hopkins University, then opened the discussion on the theory of the dynamo-electric machine. He stated that neither time nor opportunity offered for more than a general inquiry into some of the theoretical considerations affecting dynamos. One of the first and most important considerations was that of the causes of loss of power. These he divided into five—mechanical friction, Foucault currents, the current used in sustaining the magnet, the heating effects on the revolving coil, and the production of self-induction in the coil.

The first two of these needed no discussion. Their remedies were obvious and had already been applied. Under the third head the speaker suggested several possible causes of loss of power, such as the use of wrought iron instead of steel in the magnets, the elongated shape of the cross section of the magnets in some of the forms, and especially on the duplication and multiplication of magnets. The form of the poles of the magnets was also a possible cause of loss of energy. He showed how in several forms of the machine leakage of magnetic force would occur. His deductions were that the magnets of a perfect dynamo must be circular in section, of one pair of poles and perhaps of steel; that the poles should be of large size approaching closely to the armature, and that opportunities of leakage should be avoided as much as possible. He believed, with reference to the fourth cause of loss of power, that more was lost than was generally understood.

In the Gramme ring he thought that as much as one half the electric energy was wasted in what was called "dead" wire. In the Siemens armature the loss, while not so great, was yet probably very considerable. In the same way the distance which separated the poles of the magnet from the armature was "dead." The fifth cause he would leave to be discussed by Professor Fitzgerald.

The speaker then proceeded to elucidate by formulæ the strength of the magnetic field, the force necessary to expend in magnetisation, the weight, and, finally, the efficiency and speed of a theoretically perfect dynamo machine of any given size.

His results show that leaving out of the question various minor mechanical considerations, size had nothing to do with efficacy. The increase of efficiency he showed must be due to the greater proportional speed of the armature, and to other considerations.

Professor Francis J. Fitzgerald, of Dublin, Ireland, considered the loss in the dynamo machine from the induction of local currents in the coils. He showed how the sudden reversal of the direction of the current occurred under the brushes of the machine, and how in faulty construction of these brush contacts short circuiting and loss occurred. He agreed with what Professor Rowland put forward, but criticised the statement that the efficiency did not depend on the increase of size, pointing out that several causes of internal resistance, notably in the loss from separation of the armature from the poles of the magnet, did not increase with the increase in the size of the machine.

Professor Elihu Thomson criticised the paper of Professor Rowland in many points. He did not believe that extension of the poles of the magnet would be followed by a gain, since loss by radiation into the air would be inevitable. Neither did he see the objection to having a double magnet with the

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poles joined and the armature in the centre. He thought that the loss would be far less than where the poles were placed upon and within a few inches of an iron base plate, and with the armature revolving on the internal lateral surface of the poles.

As to the use of steel he had made extensive practical experiments, and had found nothing which was so suitable as was soft malleable iron. In the matter of the "dead" wire of the Gramme ring, as represented by Professor Fitzgerald, he thought that the "loss" was based on a mistaken theory, and that there was no "dead" wire, save possibly at the moment of changing the direction of currents; certainly the statement that fully half the wire was dead was incorrect. He also criticised Professor Fitzgerald's statements as to the internal self-induced currents of the armature.

At this point the discussion was interrupted and a recess ordered until 3 p.m. On reassembling Professor Rowland took the floor to reply to Mr. Thomson's remarks. He claimed that he was correct in stating that steel could be as easily magnetised as iron, and that his experiments in previous years had proved the fact. He reiterated his views with regard to the proper form of magnets and poles.

Mr. N. S. Keith, with the aid of a diagram, drew out the theoretical evolution of a dynamo. He did not agree with Professor Rowland in regard to single magnets, but preferred the form in which the poles were joined and the armature revolved in their mutual axis. He believed that in such machines there was a concentration of the lines of force along the axis of the conjoined magnets. In a single magnet the concentration occurred at the end and not on the lateral surface of the pole, where the armature was placed.

Professor Silvanus P. Thompson, of Bristol, England, gave a comprehensive account of the mathematical laws governing the construction of dynamo machines. His remarks were illustrated by formulæ, which cannot be reproduced here, but some of his conclusions from these formulæ were important.

He believed that future progress in dynamo electricity would not be gained by increasing either the speed or the amount of wire on the armatures, but by increasing the force of the field magnets. He did not agree with Professor Rowland as to the cylindrical magnets being invariably the best form, and pointed out the defects where several cylindrical magnets were joined to a single pole. He was sure that the effects of magnetism were much better where the lines of magnetic force corresponded with the grain of the iron, and hence that the magnets were always best when made of wrought rather than cast iron. He did not agree with the president either in thinking that the double magnet machine was necessarily a bad form. In connection with the form of magnets he stated that he had proved that the entire mass of the iron does not magnetise equally, and that it is possible to have currents of magnetic force inside the core of the magnet itself.

Professor Rowland attacked this statement, which, he said, was evidently a mistake, and that, if true, it would strike at the foundations of all the acknowledged laws of magnetism.

Mr. Thompson replied that he had performed experiments which proved the fact.

Professor Forbes made an explanation reconciling the discordant results. The discussion became general on the methods and time required to saturate masses of iron, and the advantages and disadvantages of a slow or quick magnetisation of the field magnet.

Professor Newcomb introduced the report of the Committee to Consider the Advisability of Establishing a Bureau of Physical Standards.

The resolutions as agreed upon were as follow:—

Whereas, the rapid increase in the applications of electricity requires the adoption and legalisation of common standards of electrical measures to form the basis of contracts for the supply of electricity; and

Whereas, the realisation of such standards requires that all instruments for electrical measurements shall be tested and verified by one central authority; therefore, be it

Resolved, that this Conference deem it of importance that Congress, in pursuance of its constitutional authority to fix a standard of weights and measures, should fix a standard of electrical measures, and in order to secure the use of such standards should establish a bureau charged with the duty of examining and verifying instruments for electrical and other physical measurements.

Resolved, that the President of this Conference be requested to communicate the above resolution to Congress through the proper official channels.

Resolved, that the United States Electrical Commission conducting this Conference shall appoint a suitable committee to represent this Conference before Congress, and to move for such legislation as will secure the object of these resolutions.

After discussion by Captain Michaelis, Professor Newcomb, and Mr. Preece, the resolution was finally carried.

A motion to adjourn finally on Saturday, at noon, subject to a call of the Electrical Commission, was carried, and the Conference adjourned. The subjects to be discussed, should time permit, in the order of their naming are:—"The Electrical Transmission of Energy," "Storage Batteries," "Underground Conductors," and "The Measurements of Currents of Large Volume."*

ON A STANDARD TANGENT GALVANOMETER.†

BY PROFESSOR SILVANUS P. THOMPSON.

It is known that in those tangent galvanometers wherein the coil consists of numerous turns of wire, the simple formula used for the case where the coil consists of a single turn of given radius is no longer applicable, but requires the introduction of certain corrections, depending on the breadth of the coil, and on its radial depth. A coil of great radial depth in proportion to its breadth acts as if its effective mean radius were less than the arithmetical mean radius of the various turns, because of the greater effect of the inner turns which are nearest to the needle. A coil of great breadth in proportion to its radial depth acts as if its mean radius were greater than the arithmetical mean radius of the several turns, because those turns which lie on the ends of the annular cylindrical surface are at a greater distance from the needle.

Now, since the effects of breadth and depth are opposite, one making the effective mean radius greater, the other making it less than the actual mean radius, it is evident that there ought to be a certain possible proportion between depth and breadth, which, if observed in the construction of the coil, will have the effect of causing these two influences to cancel one another. The object of this paper is to make known that proportion which fulfils this condition.

Maxwell has in his treatise made a similar calculation for the case of the Helmholtz two-coil galvanometer, for which he finds that the proportion between breadth and depth ought to be 31:36. Maxwell's equations (see Art. 711 "Electricity and Magnetism") also furnish a basis for the calculation which it is desired to apply to the one-coil tangent galvanometer.

We will adopt Maxwell's nomenclature, and write:—

A = arithmetical mean radius.
ξ = depth of coil in radial direction.
η = breadth of coil in axial direction.

Then, we may write as the value of the current i (in absolute measure) the following expression, involving a series of spherical harmonics as functions of the angle θ between the axis of the needle and the axis of the coil

$$i = \frac{H \cot \theta}{G_1 g_1 + G_2 g_2 Q'_1(\theta) + G_3 g_3 Q'_2(\theta^2) + \&c.};$$

where the coefficients G_1 G_2, &c., refer to the coil, and g_1 g_2, &c., to the needle, and H is the horizontal magnetic field at the centre of the coil. For a symmetrically hung uniformly

* Reference to the further meetings of the Congress will be found at the end of our correspondent's letter, given in another column.

† A paper read before the American Association for the Advancement of Science (Section of Physics). September, 1884.

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magnetised needle of length $\frac{1}{2} l$, and for a coil of rectangular section, the following are the values of the coefficients :—

$$g_1 = 2\,l.$$
$$g_2 = 0.$$
$$g_3 = 2\,l^3.$$
$$g_4 = 0.$$
$$G_1 = \frac{2\,\pi\,n}{A}\left\{1 + \frac{1}{12}\frac{\xi^2}{A^2} - \frac{1}{8}\frac{\eta^2}{A^2}\right\}.$$
$$G_2 = 0.$$
$$G_3 = -\frac{\pi\,n}{A^3}\cdot\left\{1 + \frac{1}{2}\frac{\xi^2}{A^2} - \frac{5}{8}\frac{\eta^2}{A^2}\right\}.$$
$$G_4 = 0.$$

The higher terms may be neglected. The principal term to take into account is, of course, G_1. Looking at the numerical coefficients of the terms containing ξ and η in this expression, we see that these terms will vanish, provided

$$\frac{\xi^2}{12} = \frac{\eta^2}{8},$$

which is therefore the equation of condition, and may also be written :—

$$\xi : \eta :: \sqrt{3} : \sqrt{2}.$$

The nearest convenient whole numbers that suit this relation are 11 : 9, and this is very nearly accurate, as the exact proportion is 11·016 : 9.

Accordingly the author has constructed a galvanometer on the following plan :—A mahogany ring was built up, and turned so as to have a rectangular channel 2 centimetres broad and 2·5 centimetres deep, the mean radius of the channel being slightly over 25 centimetres. Some silk-covered copper wire was chosen, of such calibre that nine turns would exactly lie side by side in the channel; and eleven layers were wound, making 99 turns in all. Each layer when wound was separately paraffined, the paraffin being smoothed off so that the turns of wire lay in square order above one another. The advantage presented by a coil of this aperture is that when it is set up the magnetometer for determining H can be set up *in situ* at the centre of the coil; and in fact the same magnet arrangement used for the deflection experiment is used as the magnet of the galvanometer. It consists of 4 pieces of watchspring each 1 centimetre long, mounted behind a vane of mica.

Here, then, $g_1 = 1$, $g_3 = \cdot 25$. If the $\eta\ \xi$ were *exactly* as $\sqrt{2} : \sqrt{3}$, then G_1 would have the value $\frac{198\pi}{25}$. As a matter of fact it differs from that value by less than one one-millionth part, the term in brackets in the full expression for G_1 being equal to $1 - 0{\cdot}000005$. The term G_3 also becomes very small, for though the dimensions 9 : 11 in the cross-section of the coil do not in this case entirely eliminate corrections, owing to the different coefficients, the fact that these corrections have to be divided by the third power of the arithmetical mean radius makes them negligibly small. The error thereby introduced, even for large deflections of the needle, is far less than the errors inevitable in the determination of H, which cannot be relied upon, except by taking the mean of a very large number of observations, to a greater accuracy than one part in one thousand.

VARIATIONS IN THE PHYSICAL PROPERTIES OF BISMUTH IN A MAGNETIC FIELD.

BY M. HURION.

Recent experiments by M. Leduc, which it is easy to repeat, show that, if a plate of bismuth be placed in a magnetic field at right angles to the lines of force, the equipotential surfaces of a current traversing the plate become deviated from their original direction, whence it follows that the physical constitution of the metal becomes altered. This change may be illustrated by other effects, especially by the action on polarised light.

The experiments of Dr. Kerr have shown that a steel mirror placed between the poles of an electro-magnet brings about a certain change of angle in the polarisation plane of a ray striking perpendicularly when the current is sent through the electro-magnet, the rotation taking place in a reverse direction to that of the current which causes the magnetisation. Bismuth has similar properties, as shown by the following experiments :—

A mirror is procured, the reflecting surface of which is composed of bismuth, made by running this metal in a molten state on to a glass plate, heated in accordance with M. Righi's practice.

The glass plate with a thin coating of metal is placed between the poles of an electro-magnet, the armatures of which are pierced with a central hole. One of them is flat and the other conical; and the light arrives by the hole of the latter.

The ray reflected normally returns to its original direction, and meets, at an angle of 45°, an unsilvered glass which allows the direct light to pass and throws back the reflected ray laterally. The incident light traverses the polarising system of a Laurent saccharimeter; and the reflected light is received in the analyser of the same apparatus. The electro-magnet may be traversed, sometimes in one direction and sometimes in another, by the current of a Gramme machine.

It is observed that the plane of polarisation of the reflected ray diverges about 30′ when the direction of the current is reversed, the rotation being in the same direction as the current which causes the magnetisation. It is clear that the effect observed is partly due to the action of the glass plate.

In order to account for this last action, the bismuth may be removed from a small portion of the glass plate, and, placing the analyser at the other end of the apparatus, the ray transmitted may be observed. It will be found that the polarisation plane of the light which has traversed the glass turns through an angle of 24′ when the direction of the current is changed, the rotation taking place in the direction of the current. Now, in the first experiment, the glass plate, being traversed by the light twice, should have produced a rotation of 48′, but the observation has given 30′. It must be concluded from this that the bismuth has caused the polarisation plane to make an angle of 18′, in a direction contrary to that of the coil current.

This result may be compared with the effect produced by a steel mirror under the same conditions, experiment showing a rotation of 22′ in a direction contrary to that of the electro-magnet. If the steel mirror be covered by the plate carrying the bismuth mirror, a rotation of 28′ in the direction of the current will be observed, whence it may be concluded that the effect due to the glass plate will be found by adding to this rotation that produced directly by the steel, which gives for the effect of the plate 50′ instead of 48′, the number found above. The verification is therefore satisfactory. Experiments now being carried out have shown that the electric resistance of bismuth increases when placed in the magnetic field.—*Journal de Physique.*

ELECTRIC LIGHT INSTALLATION IN THE LEIPZIGER-STRASSE AND POTSDAMER PLATZE, BERLIN.

Fr. von Henfner-Alteneck describes in a previous paper in the "Electrotechnische Zeitschrift" the engineering details of this installation. The present deals particularly with the commercial results, which are especially interesting, as the circumstances were such as to allow a fair comparison with gas. The installation consisted of thirty-six arc lamps, and the average length of time each arc was in use during the year was 1,900 hours, giving a total of 68,400 lamp hours. Gas engines were used entirely for motive-power, the gas supplied being of the same quality as that used simultaneously for lighting the neighbouring streets. The price of the gas was taken as 13.3 pfennige per cubic metre (approximately 3s. 9d. per 1,000 cubic feet), which is the estimated cost of the gas used for street lighting by the municipality of Berlin, and somewhat less than the retail price. The following is an

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analysis of the cost of maintenance from the 20th September, 1882, to the 20th September, 1883 :—

	Marks.
Gas consumed (including the lighting of the machine house)	10,156
Water	1,654
Oil and waste	2,096
Carbons for the arc-lamps	5,472
Repairs	540
Labour and attendance	3,836
Rent of ground for the machine house	300
Fire insurance	91
Sundry disbursements	390
	24,535

The author points out that as each arc light required about 1 horse-power the cost of the motive power per horse-power hour is about 20 pfennige, or 2·4d. With a steam engine in place of the gas engines this might be reduced to 0·6d. The actual cost to the municipality of lighting an equal length of the neighbouring streets by gas, though not with the same illumination, was 26,000 marks.

The author proceeds to discuss the question of the depreciation of the plant, and makes, in passing, the interesting observation that the cable employed, which consisted of a copper wire served with steeped hemp and sheathed with lead, showed no signs of deterioration, although subjected to an electromotive force of 650 volts.—*Abstract, Inst. Civil Engineers.*

FATAL ACCIDENT FROM A DYNAMO AT THE HEALTH EXHIBITION.

On Saturday evening, shortly after seven o'clock, Henry Pink, about twenty-one years of age, an attendant in the electric light shed of the Health Exhibition, employed by the Commissioners under Mr. Gooch, the general superintendent of the electrical department, met his death by incautious contact with one of the dynamos used for supplying the electric light. As there has been a great deal of misrepresentation in connection with this sad event, we have been at considerable pains to ascertain the true facts of the case ; and we have been greatly aided in our endeavours by the engineer to the makers of the dynamo, who court the fullest investigation.

It was Pink's duty merely to go round and oil the dynamos, and to ascertain that they ran smoothly and without heating ; and he had been repeatedly cautioned never to touch them with both hands at once. It appears that the deceased had accomplished this duty, and, according to the evidence of a visitor who saw the whole of the sad occurrence, was standing near the larger of the two Hochhausen dynamos, of American manufacture, supplied by Messrs. Edmunds and Goolden, of 2, Victoria Mansions, Westminster, S.W. This machine supplies 25 arc lamps in a single circuit, generating 11 amperes at 1,200 volts. But lately, by desire of the Commissioners, it has been forced beyond its normal duty, so as to maintain 29 lamps, and has consequently been the object of special attention. It may here be mentioned that, since the sad event occurred, this machine has been carefully tested by the electrical staff of the Exhibition, and has been found in perfect working order.

The above-named visitor, Mr. William H. Tilley, whose detailed evidence is reproduced below, saw Pink aimlessly playing with the large Hochhausen dynamo, having his left hand on the upper brushes, and turning half round so as to face the dynamo, having his back to the barrier which prevents the public from approaching the machines. He then mechanically brought his right hand on to the bearing at the top of the standard, as though to feel if it were warm, without removing his left hand from the upper brushes, and then, it is supposed, placed his right hand on the lower brushes, when the fatal event followed. Death, however, was not instantaneous, and, indeed, did not ensue until fully ten minutes after the contact must have been made. It is not conclusively established that the unfortunate man actually touched both brushes at once, though it is proved that he touched the upper brush with the left hand and the spindle bearing with his right. There are therefore two theories as to the immediate cause of death. One that he died from the effects of the shock caused by the full current of the machine, which appears to be the one generally received ; and the other, that he only received the shunt circuit between the upper brush and the bearing, and that death ensued mainly from fright at having received this shock of minor intensity.

The inquest was held on Wednesday, at St. George's Hospital, by the Coroner for West Middlesex, Mr. A. Braxton Hicks, when the case was watched by Mr. A. P. Bower, for Messrs. Edmunds and Goolden, and by Mr. Arthur C. Moore, for the Executive Council of the Health Exhibition.

Charles Pink, tobacconist, of 435, Edgware-road, identified the body of the deceased as his son, who had been an attendant in the electric light shed since the opening of the Exhibition. He had never before been employed in connection with electricity ; but had been in the habit of reading books on the subject, and knew perfectly well the risk he was running, and had even spoken of the painlessness of a possible fatal accident.

William H. Tilley, plumber, of Normanton, Rutland, who gave his evidence in a remarkably clear manner, stated that on Saturday last he was a visitor at the Health Exhibition. About half-past six in the evening he went into the electric light machine room, and witnessed the working of the dynamos. He saw the deceased put his left hand on the brush of the 25-light dynamo, and rub his finger up and down close to where the witness saw some sparks issuing. He had until then been almost facing witness, at right angles with the dynamo shaft ; but he now turned round, so as to directly face the dynamo, and put his right hand on the bearing at the top of the standard, as though to feel if the bearing were warm, and without removing his left hand from the brush. He then slowly brought his right hand towards the lower brush. Witness could not swear that he actually saw deceased touch the lower brush ; but he observed him give a convulsive clutch, and then appear unable to take his hands away. At that time he had both hands on the machine. His head went gradually back ; and then he let go with his left hand, and fell backwards against the barrier, where witness was standing. All this took place in the time one might count three. Deceased then fell back on his right side, when another attendant came up and caught him. Some water was fetched, and his hands were chafed. Brandy also was brought, but was not administered. [The poor fellow was too far gone.]

On a plan of this part of the dynamo shed and a drawing of the machine being produced, witness pointed out the brushes and other parts of the machine alluded to. Respecting the report that the deceased had an oil can in his hand at the time of the accident, witness distinctly stated that this is incorrect.

Eli Bates, electrician, an old servant of Messrs. Edmunds and Goolden, but who had been temporarily handed over to the Exhibition Commissioners, said he was in charge of the machines and the lamps, and the deceased was his assistant. There were two machines. His business at night was to go round and look after lubricators and feel the bearings. When Pink first came to work witness told him not to touch the framework and the brushes at the same time. He was told not to touch the brushes at all. The lubricators were of glass and filled with oil. [A lubricator was produced, showing it to be a glass vessel encased both top and bottom with brass, which was removed from the bearing to be filled.] In answer to questions, witness said it was perfectly safe to touch the machine with one hand. He had scores of times warned Pink against touching it with both hands at one time.

T. Clark, an electrician in the employ of the Brush Company, and in charge of a neighbouring machine, said he saw the deceased stagger against the barrier, with his hands stretched out towards the dynamo. He called Bates' attention to the fact, saying, "Your mate has fainted." He and Bates went to his assistance, and he vomited a white substance like milk, and was then carried away. In answer to the jury, he stated that he considered the machine to be perfectly safe.

Mr. George E. Bloxham, house physician at the above hospital, stated that the man was quite dead when admitted. There were no external marks excepting a mark, as though of a slight burn, between the fore finger and thumb of the left hand. A *post-mortem* examination was made. All the appearances pointed to death from shock by electricity, the condition of the heart and veins, together with the state of the blood, being consistent with death from that cause.

Alexander P. Trotter, civil engineer, engaged on the staff of Messrs. Edmunds and Goolden, produced a diagram of the machine, and briefly described its working. He stated that it was a matter of common knowledge to the workmen and attendants that it was highly dangerous to touch such a machine with two hands. He added that he was in the habit of regularly examining the machine, and feeling it with one hand. There were two classes of machines, one of which was not dangerous [the incandescent], but this one worked twenty-five or more arc lights upon one wire, thus producing twenty-five times the force required for one lamp. If the two brushes were touched, one with either hand, a current would pass through the body of the deceased, which would undoubtedly prove fatal. In reply to Mr. Arthur C. Moore, solicitor to the Executive Council of the Health Exhibition, who asked if every

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reasonable precaution had been taken against accidents, witness replied distinctly in the affirmative, and took the opportunity of stating that there had been a distinct but unfounded charge of cruelty brought against the owners of the machine for not providing india rubber boots and glass oil cans for the attendants. [This charge was made by a correspondent to a morning paper, who said he had been an eye witness of the accident, and who further took upon himself to say that there was sufficient earth leakage from most machines to cause a fatal shock, if any part were merely touched by a metal oil can. This gentleman had been summoned as a witness; but, as it turned out that he only saw the deceased carried out, and that his other statements were mere assumptions, his evidence was not taken.] Mr. Trotter further stated that there was no necessity for taking an oil can to the lubricators, as they could be removed and then filled.

The Coroner, in summing-up, remarked that it was evident the deceased had been fully warned, or otherwise the accident would have occurred during the first week of his engagement.

After a brief deliberation the jury, in returning a verdict of accidental death, expressed their opinion that, though there was no danger to the public, a notice that the machines should not be touched with both hands at the same time should be posted at the spot.

"Electricians who are anxious to promote the popularity of the new light would do well to pay special attention to whatever means there may be of obviating such accidents as that which befel one of the men engaged in the dynamo shed at the Health Exhibition on Saturday night." So says the *Daily News*, in commenting on this unfortunate accident; and we are entirely of the same opinion. Further, we see no reason why such accidents should not be rendered impossible. The use of an india rubber glove, worn on the left hand, so as to leave the right free for work, in the case of an ordinary right-handed man, should be made compulsory on all who have the conduct of high-tension dynamo machines, and a few short and plain rules should also be printed in large type, and posted up prominently in the neighbourhood of the machines. Apart from humanitarian considerations, the effect which this sad accident is likely to exert on the cause of electric lighting is most serious, in the direction of destroying confidence, especially among those who look only at the sad effect, without going thoroughly into its cause—simple negligence.

PROFESSOR ROWLAND'S PRESIDENTIAL ADDRESS AT THE PHILADELPHIA CONGRESS.

To the student of science who has a disposition to look into the pages of history, no life has greater interest than that of Archimedes, and yet there are few men about whom so little is known. Living more than 2,000 years ago, the accounts of him which have come to us are little short of fabulous, and yet they are of such a nature that we can say without any doubt that he was a genius such as the world has seldom seen. To him we owe some of the fundamental facts of mechanics, such as the principle of the lever and the pulley, and the fact that a body immersed in a liquid loses in weight as much as an equal volume of liquid weighs. And in military engineering his success was so great that he prolonged the siege of Syracuse by the Romans from what would probably have been a few days to three years. His engines shot against the enemy immense numbers of darts and huge stones, which mowed them down in columns, and falling on their ships destroyed them. He thrust out huge beams from the walls over the ships, and drew them into the air, where they swung to and fro to the amazement and terror of the Romans, and were finally dropped and sunk to the bottom of the sea. He is even said to have set them on fire by means of the reflected light of the sun. But his principal work was in geometry, and of this I only need to quote the words of Professor De Morgan referring to those geometrical works of Archimedes which have come down to us. "Here," says Professor De Morgan, "he finds all that relates to the surface and solidity of the sphere, cone, and cylinder and their segment. A modern work on the differential calculus would not give more results than are found here." As to the quality of the individual, the impression which his writings give us is that of a power which has never been surpassed. No one has a right to say that Newton himself, in the place of Archimedes, could have done more.

Thus before the birth of modern science, in the dim ages of the past, when the light of history begins to fade and the mist of legend to cover our view, there lived a man of almost superhuman intellect, whose mind seemed equally adapted to either pure or applied science. And yet Plutarch says of him, "Archimedes possessed so high a spirit, so profound a soul, and such treasures of scientific knowledge, that, though the inventions (referring to his military engines) had now obtained for him the renown of more than human sagacity, he yet would not deign to leave behind him any commentary or writing on such subjects; but, repudiating as sordid and ignoble the whole trade of engineering, and every sort of art that lends itself to mere use and profit, he placed his whole affection and ambition in those purer speculations where there can be no reference to the vulgar needs of life—studies, the superiority of which to all others is unquestioned, and in which the only doubt can be whether the beauty and grandeur of the subjects examined, or the precision and cogency of the methods and the means of proof, most deserve our admiration."

Here, then, at the dawn of science, the question of the relative value of pure and applied science had been brought up. To the people of Syracuse, who had to defend themselves against an overwhelming enemy, the military engines of Archimedes were of far more interest than the whole of geometry, for the knowledge of the ratio of the solid contents of a sphere and its circumscribed cylinder cannot bring a dead man to life or restore wealth to a plundered city. And yet, from a point of view distant more than 2,000 years, we are forced to admit that Archimedes was right. Archimedes' engines of destruction have passed away, but the geometrical and mechanical truths which he discovered are to-day almost the axioms of the mathematician and the worker in physical science, and the ratio of the circumference of a circle to its radius is to-day the most important of our physical constants.

But this is only a meagre part of the influence of this man. The truths which he discovered have formed a part of the education of every student of mathematics to the present time, and have given pure intellectual enjoyment to all. They have helped to form the minds of all those whom we consider great in our science, and they have done their share in that march of progress which is gradually transforming the world.

Great should be the honour in which we hold the intellect of Archimedes, but greater should be our reverence when we approach that noble spirit which could ignore all worldly considerations, and prefer the truths of geometry to the vast physical power given him by his other inventions, which were his amusements for a moment. We now see that he was right, but we cannot for a moment suppose that he foresaw, except dimly, any so-called practical advantages from his discoveries. A thousand times no! He preferred his geometrical labours because of a subtle quality of his mind, an instinct toward that which was highest and noblest, and a faith that the pursuit of what is noble is the surest road to the final happiness of the individual and of the world. Our highest moral qualities are of this nature, and we despise as the lowest of the low one who is honest because "honesty is the best policy," but esteem him whose instincts lead him to honesty whatever the consequences.

So we reverence the noble and lofty spirit of Archimedes, and yet we do not at the present day quite agree with his estimate of the relative value of his works. His military inventions were far from worthy of being despised, even though the only reason were that they gave the world three more years of Archimedes' life. The world is not formed of disembodied spirits, but of men, in whom there is a wonderful combination of mind and matter, and a sound mind in a sound body is the highest type of manhood. But we also know that the mind is hampered by many considerations connected with the body. Archimedes recognised this, and his noble spirit revolted at it. But to-day we see that no progress can come from this method of treatment; the body still remains, however much we may despise it, and the buzzing of a fly can disturb the most profound thought of the philosopher.

We now study the laws of nature and seek thus to assist our bodies in obeying the thoughts of our minds. Our railroads carry us thither and thither on the earth with somewhat the facility of spirits, and our thoughts pass with almost the speed of light to the uttermost portion of the earth. The steam engine does our work, and labour-saving machinery takes the place of our hands. With a minimum amount of labour we can to-day possess luxuries unknown even to kings in ancient times, and our minds are free to study the order of nature or engage in any intellectual pursuit we may desire. Instead of being the slaves of nature and grovelling in the dust before her to find the food which we crave, we have now assumed the command, and find her a willing servant to those who know her language.

But here we reach the keystone of the problem. To command her we must know her language. Knowledge, then, is the price of her service, and she obeys not the ignorant or degraded, but grinds them into dust beneath her heel.

Knowledge, then, is power, and it is more than power; it is that which the intellect most craves, and is the object of many of our highest aspirations. What is the truth is the goal of intellectual mankind in all ages, and its pursuit leads not only to intellectual, but also to physical satisfaction.

The pursuit of the one leads to the other, and we shall see as we proceed that the only way for the world to progress in practical science is by the cultivation of the theoretical science.

Pure science must exist before its applications, and the truths of pure science are far more reaching in their effects than any of its applications; and yet the applications of science often have a much more immediate interest for the world at large than many discoveries in pure science, which will finally revolutionise it, both physically and mentally. They both have their importance and both are at work in causing that intellectual progress in which the world is now pushing forward with giant steps. But there is this difference—the names of the great inventors are seen in every paper and their deeds are recounted to the rising youth of the country as examples to be followed. And yet the discoverers of the principles on which their inventions are based may have died in comparative obscurity, with poverty knocking at the door. We are in no danger of forgetting those who have been successful in those applications of science which are in daily use, and it is useless to repeat the story of the telegraph or telephone, but it will be of more interest for me to recall to your minds a few of the landmarks in our science, and then to consider the present state of our science, with a possible glance into the future.

Thus we shall obtain a clearer view of how our science has been built

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up, and of the means which are necessary for its further progress. We shall also see the relation between pure and applied science, and the relative importance of the two in the progress of the world.

It is impossible for one here to discuss the reasons why the ancients followed their science to so short a distance, and the world had to wait more than two thousand years before the light of modern science commenced to shine. It must be left to the psychologists and historians. But this I may say, modern progress is cumulative. By the study of the science of the past, the minds of men are trained for its further advance in the future, and so when there was no science to study there could be but little training of the mind in the true methods of thought.

The average intellect of mankind has improved, and what could only have been comprehended in past times by a few is to-day understood by the majority of educated persons. And this increase has been most apparent in the reason and moral sense of mankind, the two qualities of the mind which come most into play in the study of science. To the mind of the ancients, where the imagination ran riot without the guide of reason or a warning from their moral sense to speak the truth, it was easier to attribute the attraction of rubbed amber to an inherent soul or essence, which, awakened by friction, went forth and brought back the small particles floating around, than to examine and find out the truth.

The simple experiment of the amber remained without investigation for 2,200 years. Had the reasoning of many modern persons been followed, we should never have had a science of electricity. Why should anybody investigate this phenomenon, this feeble force, which could only attract a few particles of dust? The world could eat, drink and take its ease without doing anything in the matter, and it did so for more than 2,000 years of intellectual, moral, and physical degradation. Then the awakening came, and men began to feel that they were reasoning beings. They began to see that there were other pleasures in the world besides animal pleasures, and that they had been placed in this wonderful universe that they might exalt their intelligence by its proper study. No question of gain entered into the minds of these early investigators, but they were led by that instinct towards truth which indicates the highest type of man. And yet their researches have transformed the world, not only intellectually, but physically. Some would say that science had been degraded by its applications, but who that looks over the world at the present time can think so? There is no danger of this view becoming general; the danger is in the other direction, and that science shall be degraded in the estimate of the world by the idea that its principal use is to be applied to the common purposes of life. A thousand times no! Its use is in the intellectual training of mankind and the high and noble pleasure it gives to those who are born to understand it; to lift mankind above the level of the brute, and to make him appreciate the beauties and wonders of nature; to cause him to stand in humiliation and awe before that universe which the intellect of ages has attempted to understand, and yet has failed; to make even Newton say: "I know not what the world may think of my labours, but to myself it seems to me that I have been but as a child playing on the sea shore; now finding some pebble rather more polished, and now some shell rather more agreeably variegated than another, while the immense ocean of truth extended itself unexplored before me."

But the great moral law of the universe here enters. If the world would only pursue those things which are high and right and noble its reward would not be confined to the minds of men. Physical rewards await it as well, and disease, that principal cause of human misery, would almost pass away when the effect of inheritance from the present generation had passed. So the pursuit of pure science brings not only the rewards I have mentioned but the physical rewards of applied science, and the pursuit of applied science gives wealth which may be again employed to further pure science. So the two react on each other to produce that perfect whole, modern science, pure and applied.

This moral law of the universe is well illustrated by the well-known story of Solomon.

"The Lord appeared to Solomon in a dream by night; and God said, ask what I shall give thee.

"And Solomon said: Thou hast made thy servant king instead of David my father; and I am but a little child; I know not how to go out or come in.

"Give, therefore, thy servant an understanding heart to judge thy people, that I may discern between good and bad; for who is able to judge this so great people?

"And God said unto him, because thou hast asked this thing, and hast not asked for thyself long life; neither hast asked riches for thyself, nor hast asked the life of thy enemies; but hast asked for thyself understanding to discern judgment. Behold, I have done according to the word; lo, I have given thee a wise and an understanding heart; so that there was none like thee, neither after thee shall any arise like unto thee.

"And I have also given thee that which thou hast not asked, both riches and honour; so that there shall not be any among the kings like unto thee all thy days."

So the world, when it chose knowledge and truth above all things, acquired not only the treasures of pure theoretical science, but also the wealth and riches and honour which come from applied science such as the world has never seen before and could see in no other way.

It is to William Gilbert, an English physician, that we owe the commencement of the modern science of electricity. His book on the magnet was published in 1600 and contained his electrical experiments. Thus, at this early date the similarity of electrical to magnetic attraction was recognised. But how slowly did the subject advance! The difference between conductors and non-conductors was discovered by Grey. But not until 1746, 150 years after Gilbert, was the Leyden jar invented. Then the remarkable nature of the phenomenon became apparent, and the world was startled by it. The subtle spirit which went forth from the amber, which was so feeble as only to attract dust, now flashed forth with light and sound and heat, and could cause the strength of the giant to vanish. To the world at large there was now something worth looking into. But do we think that the spark from the Leyden jar is more wonderful than the gentle attraction of the amber? By no means, for, to the scientist, they are both equally remarkable and beyond our powers of explanation. It is only to the vulgar and uneducated taste that the tinsel and gew-gaws of an electric spark appeal more strongly than the subtle spirit of the amber. Nevertheless, despicable as the means, the spark of the Leyden jar acted as a trumpet call to Europe and even America to come to the study of the wonderful science of electricity. At no other time has there been such excitement over any electrical discovery, and electrical experiments became general.

It was only after the discovery of the Leyden jar that the idea of an electric current occurred to mankind, and this current was even transmitted to a distance by a wire and a shock given to a person across the Thames, the water forming the return circuit. And the English experimenters even went so far as to form a circuit with the two observers two miles apart, using the earth as the return circuit. Thus the fundamental fact which forms the basis of the telegraph was early observed.

But isolated facts are of little value unless connected together by something which we call a theory, and in this line we owe much to Franklin, whose letters on this subject appeared between 1747 and 1754. To him we owe the theory of positive and negative electricity, and the fact that they are always generated in equal amounts, a law whose importance can scarcely be estimated. He investigated the Leyden jar, and showed that the coatings had equal positive and negative charges, and explained the fact that the jar cannot be charged when the outside coating is insulated. He invented the charge and discharge by cascade, and showed that it was the glass of the jar and not the coatings which contained the charge. He discovered the property of points in discharging an electrified body and the identity of lightning with electricity. He also made the first experiments upon atmospheric electricity.

To Canton is due the honour of giving the first experiments of induction, but Franklin is the first who gave the general law of this species of action. Truly our country and this city should honour the memory of this man.

But it is not my purpose to repeat to you in detail the familiar history of our science. Thus far, no important applications of electricity had been discovered; there was nothing but pure science to attract investigators, and thus the science remained for many years after.

But no science is complete unless it is quantitative as well as qualitative. It is now very nearly 100 years since Coulomb laid the foundation of electro-statics and Alpinus and Cavendish commenced to lay the foundation of mathematical electricity, and they were followed by Laplace, Biot, Poison, and Murphy.

The discoveries by Galvani and Volta in 1790 and 1800, and by Œrsted in 1820, gave us the galvanic battery and electro-magnetism, and it was not until the latter date that any useful practical application was possible. Then, so complete was the science that no factor of other than minor importance was necessary to transmit intelligence from one extremity of the earth to the other.

By the labours of the immortal Faraday, electro-magnetic induction was discovered and the modern dynamo-electric machine became a certainty.

To his other labours, both experimental and theoretical, the modern science of electricity owes much, but it is familiar to all. The name of Faraday needs no eulogy from me, for it stands where it can never be hidden, and the spark which Faraday first kindled now dazzles us at every street corner. No wealth came to him, although he had only to hold out his hand for it. But the holding out of one's hand takes time, which Faraday could not spare from his labours, and so the wealth which was rightly his went to others. Who will follow in his footsteps and live such a life, that the thought of it almost fills one with reverence? It is not only his intellect which we admire, it is his moral qualities which fill us with awe, his noble and unselfish spirit.

The name of Faraday brings us down to modern times, whose history it is unnecessary to repeat in detail, especially as there are some now present who have contributed largely to bring the science to its present perfection.

One of the principal features which we remark in our modern science of electricity is the perfection of our means of measuring both electrical and magnetic quantities. In this connection the great names of Gauss and Weber appear, the fathers of the modern absolute system of electrical and magnetic measurement, and that of Sir William Thomson, in no degree less distinguished. On the laws of electric attraction we base our electrostatic system of measurement, and on the magnetic action of the current, the great discovery of Œrsted, we base our electro-magnetic system and we connect these two systems by that great physical constant, the ratio of electro-magnetic to the electro-static system of units.

What can be simpler in theory than the electro-static system, based as it is on the law that electric attraction varies inversely as the square of the distance? We only have to know how the electricity is distributed and its attraction is known. Hence we must select the simplest possible case, such as two parallel discs, and to render the problem calculable, we add a guard ring to the movable disc. We then have the absolute electrometer of Thomson. This gives us a measure of the electric potential. Knowing the capacity and difference of potential of the surface of a condenser, we know its charge. But all these quantities, the calculation of the electrometer and the capacity of the condenser, depend upon the mathematical theory of electric distribution. Are we able to calculate the capacity of condensers of all forms? I am sorry to say we are not. The modern method of treatment is due to James Green, an English investigator, whose name should be held in honour by all electricians. But this method is what is called an inverse one. It is not a method by which we can calculate the distribution on any body at random, but the shape of the body and the electrical distribution on it are both found at once by a

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species, as it were, of exploration and discovery. So that we cannot make our electrometers and condensers of any shape and then calculate them, but we are forced to make them of some simple geometrical form whose solution is known. We fit our apparatus to the mathematics rather than the mathematics to the apparatus.

But when we have satisfied all the conditions we measure out our static charges as easily as a quantity of matter. The manufacturer sells the oxygen and hydrogen in iron cylinders, and determines the amount by the product of the capacity of the cylinders by the pressure. Were there any buyers of electricity we might sell them a Leyden jar full, and determine the amount by the product of the capacity of the jar by the electric potential. According to this analogy, then, the electricity is similar to matter and the potential to fluid pressure, while the word capacity has a similar meaning in both.

In the electro-magnetic method of electrical measurement we make use of the magnetic action of the current, either on a neighbouring magnet or another current or portion of the same current. The laws of the action of a current on a magnet were discovered by Biol and Savart, and of two currents on each other by Ampère, and the results applied to practical measurement to-day give us galvanometers of all kinds and the electro-dynamometer of Weber. By the galvanometer we can measure the quantity of electricity passing at any moment, but by the electro-dynamometer we measure the integral square of the current, a quantity on which the heating of the circuit and the energy expended depends.

Thus the electro-dynamometer measures the energy from an alternating current dynamo-electric machine as easily as from one giving a continuous current, but to know this energy we must know something else besides the integral square of the current, and this is either the resistance of the circuit or the electromotive force. But the measurement of electromotive force depends on a resistance. The question then comes up as to what unit of resistance is the proper one. Here we have to refer to the mathematical theory of the subject, and the great law of the conservation of energy tells us that what is known as the absolute unit of electrical resistance is the proper one for use in this case. Hence the great practical use of determining this unit. The experiments of Kirchoff, Weber, Kohlrausch and the British Association found a value from one to three per cent. too large.

(TO BE CONTINUED.)

COMPANIES' MEETINGS & REPORTS.

Direct Spanish Telegraph Company (Limited).

The twenty-second ordinary general meeting of this Company was held at the offices, Leadenhall-buildings, Leadenhall-street, E.C., on the 29th September, under the presidency of Mr. Neil Bannatyne.

The MANAGER (Mr. Ch. Gerhardi) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: From the report and accounts you will be able to form your own opinion as to the present position of the Company, with the aid perhaps of one or two remarks which I shall now make. Although the receipts are, as stated in the report, £243 in excess of those for last half year, the working expenses are only £12 more, and they are £56 less than for the corresponding half of 1883. I need not say to the shareholders that the Board will continue to give their best attention not only to promote the traffic of the Company, but also to keep down the working expenses as much as possible, consistently with the efficiency of the line. It will, perhaps, be in the recollection of the shareholders that—I think it was at the last meeting or the meeting before—I mentioned that the amount of debentures we thought we should have to issue for the payment of the new cable, &c., would be about £65,000. I am glad to state, however, that from our having a quantity of new cable in stock, we now expect that the sum of £62,000 will be sufficient to pay for the new cable and connections. The Board have been able to make arrangements for the more rapid settlement of the quarterly accounts, and in consequence they expect they will be able to pay the dividend on the preference shares in the course of about a week after the meeting, instead of six weeks or two months, as has been the case on the last two or three occasions. As regards the prospects of traffic for the half year which commenced on the 1st July last, I may state that the July receipts were £1,496, those for August £1,173, and those for September—estimating the amount upon the returns for the first twenty-six days—will probably be £1,650. This is the best month since the half year commenced, but the total shows a decrease of £313 on the corresponding period of last half year. This decrease is fully accounted for by the great falling off of trade in Spain, in consequence of the quarantine regulations established by the Spanish Government on account of the cholera epidemic. This quarantine has greatly affected the shipping trade with Spain, upon which the greater part of the traffic of the Bilbao cable depends. On another side, the traffic of the Barcelona-Marseilles cable has been much affected by the cholera, business in both these towns being at a complete standstill. Although no actual outbreak took place at Barcelona, 50,000 people of the better classes, including merchants, stockbrockers, &c., who give us our business, left that town. As an instance of the effect of the epidemic upon trade in Spain, the well-informed correspondent of the *Standard* at Madrid states that "there has been a decline of about one million sterling in the revenue since the middle of June, and a decline of several millions sterling in the values of the exports and imports." In the presence of these facts, we can almost congratulate ourselves that our traffic, which is solely dependent on the Spanish and French business, has not suffered more. Of course, you are all aware that the stagnation of business is not confined to Spain, but is general everywhere and in almost every department of commerce. During the severe outbreak of cholera at Marseilles, our staff in that town behaved very creditably, and stuck to their posts. The Board took steps to make them as comfortable as possible during this trying period. I think I have nothing else to add, but if there is anything in the report or the accounts on which any shareholder would like to put any questions, we will do our best to answer them to their satisfaction. I think, considering the adverse circumstances of the past half year—although we should, of course, like to be in a better position—we may congratulate ourselves that we are no worse off. He concluded by moving the adoption of the report and accounts.

Mr. HUNTER presumed that there was no intention of restoring the original cable for some time, and so spending more capital on the old cable.

The CHAIRMAN: No, I believe it is the intention of the Board at present to take no steps with regard to that matter. It may be our interest by and by to put that cable into working order again, but we shall be quite ready, when circumstances make it our interest to do so, to proceed in that matter then.

Mr. BEARD: What is your opinion of that old cable? Is it worth going on repairing?

The CHAIRMAN: I could not give an opinion, but here is Sir James Anderson, who is very competent to do so.

Sir JAMES ANDERSON: I should not like to give it up. I think the chances are in favour of putting that cable in order some day, when we get richer, and restoring it. It would take a good deal of money to put it thoroughly in order, and it is a pity to spend money in patching.

Mr. ATTRELL inquired when it was proposed to raise the debentures?

The CHAIRMAN replied that they were all raised and issued. In further reply to Mr. Attrell, the Chairman stated that the proportion of interest due on the debentures—to the 30th of June—was paid. The ordinary shareholders must remain in abeyance until the Company was in a position to pay them a dividend. They could not be more anxious to receive a dividend than the Directors were to pay them one. It was difficult to say when that would be, as a cable company was liable to so many contingencies. They saw how the cholera had affected the receipts of the Company in the last half year. As to the directors continuing to receive, notwithstanding, their remuneration of £400 a year, they earned it by their attendance on the Board, the trouble they took about the concerns of the Company, and the attention they gave to its business generally. The directors were considerable shareholders in the Company, and they were obliged to rest content without any dividend on their investment, just as the ordinary shareholders. If any ordinary shareholders were on the register now who were on the register when the preference shares were issued, they would remember that he was chairman at the time, and strongly urged the ordinary shareholders to take up their proportion of the preference shares. He pointed out that, even if the ordinary shares received no return, the dividend on the preference shares was perfectly secure, and that by taking their allotment of the preference shares in proportion to the number of ordinary shares they held they would get a very fair return on their money, even if the ordinary shares paid no dividend. He wished to add to what Sir James Anderson had said that in consequence of their friendly and intimate relations with the Eastern Company they would be in a position to take whatever steps they might consider advisable, with greater advantage, when the time came to deal with the old cable. Of course their relations with the Eastern Company added considerably to the strength of their position, and they had always found those relations work most satisfactorily.

A SHAREHOLDER inquired if there was any limit to the present working with the Eastern Company.

The CHAIRMAN: Twenty years.

The SHAREHOLDER thought that this put them in a satisfactory position.

Sir JAMES ANDERSON: We have a joint-purse arrangement.

The CHAIRMAN: Although the old cable is doing nothing, our new cable is carrying the traffic, and could carry a great deal more.

Mr. ATTRELL: I think the best way would be to sell the whole concern to the Eastern Company. They might make something of it.

The CHAIRMAN: Well, there are two parties to a bargain. Whenever the Eastern Company say they will give us a satisfactory price, I have no doubt that, even though there are two members of the Eastern Company on our Board, we shall be able to deal with them. He then again submitted the motion for the adoption of the report and accounts.

Sir JAMES ANDERSON seconded the resolution, which was carried unanimously.

The CHAIRMAN next proposed the declaration of the preference dividend, at the rate of 10 per cent. per annum, less income-tax, for the half year ended the 30th June last. He added that they hoped to pay it in the course of ten days or so.

Mr. EDMUND ETLINGER seconded the motion, which was carried unanimously.

Mr. COCHRANE then proposed a vote of thanks to the Chairman and Directors for their conduct of the Company's business. He was, he said, one of those who felt some time ago that a change was desirable in the constitution of the Board, but he thought that the present was not the time to raise such a question. They had recently had an accession of strength on the directorate, and he had no doubt that the Board had done their best in past times to carry out what was in some respects—he did not know from what cause—an unfortunate transaction. He had some considerable amount in the ordinary shares, and would be very glad to see a dividend on them. He thought the present time was hardly that at which to blame the Directors, who seemed to have adopted the only course open to them. They had previously gone on spending a lot of money in patching the old cable, which was constantly breaking and constantly entailing fresh expenditure. He thought

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the shareholders should at least withhold commenting on the very moderate remuneration of the Board, with which he thought they could not reasonably find any fault. He very heartily proposed a vote of thanks to the Directors, and hoped that their united services might bring the Company out of what was at present a rather dull position, and that by and by they might be able to meet them with heartier feelings than at present.

Mr. KIDMAN seconded the motion, which was carried unanimously.

The CHAIRMAN: On behalf of my colleagues and myself I return you our best thanks for your vote of approval and confidence. We have done all we could to promote the prosperity of the Company under somewhat adverse circumstances, which were entirely beyond our control. We could not control the state of trade in Spain and France, or the outbreak of cholera. For myself I will only say that I have not at all lost confidence in the ultimate success of the Company. When we have a revival of trade generally, and more especially in Spain and France, I have no doubt, with our new cable and our connection with our friends of the Eastern Company, that we shall, after a moderate period of time has elapsed from the commencement of that prosperity, be in a position to give a fair return on our ordinary shares.

Mr. HUNTER inquired whether the new cable was of a different type from the old.

Mr. ETLINGER replied in the affirmative, and observed that the new cable was much stronger.

Mr. ATTRELL proposed a vote of thanks to the officers for their services in the past half year, coupled with the name of the manager.

Mr. KIDMAN seconded the motion.

The CHAIRMAN in putting the resolution observed that it had the cordial approval and support of every member of the Board.

At the suggestion of Sir JAMES ANDERSON the auditors were included in the vote, and the motion was then carried unanimously.

The MANAGER, in reply, expressed his acknowledgements, and said he would do his utmost to promote the the welfare of the Company.

The proceedings then terminated.

Great Western Electric Light and Power Company.

The Directors beg to submit to the shareholders their second annual report upon the operations of the Company, for the year ending June 30, 1884, together with the statement of accounts, duly certified by the auditors. The Directors beg to report that the necessary steps for the reduction of the Company's capital have been completed, and the assent of the Court given on August 6, 1884. The shareholders are thereby freed from any further liability in respect of their shares, and the Directors' promise on taking office is thus fulfilled. That after considerable negotiation the claim made by the liquidator of the Devon and Cornwall Electric Light Company has been settled upon the following terms:—The surrender to the liquidator of the shares held by your Company in the Devon and Cornwall Electric Light Company, and the issue to him of 3,000 fully paid shares of £2 10s. each in your Company. These terms your Directors consider fair and equitable. That the action referred to in last year's report as pending against your Company by certain shareholders in the Devon and Cornwall Company has been dismissed. Your Company is now clear of litigation, and free to carry out the objects for which it was formed. That considerable reductions have been made in the expenses of management, which, including Directors' fees, last year stood at £4,297 4s. 9d., this year £1,676 15s. 8d. This amount would have been still smaller had all the economies introduced been in force during the entire year, but it was only in March last that the Directors succeeded in placing the expenditure upon what they consider a satisfactory basis. The amount of business offering has been considerable, but only a small portion could be secured at such rates as the Directors could entertain, as they are determined to undertake no work except at a fair profit. The lighting stations at Bristol and Cardiff have been maintained during the year, and the most anxious attention has been given to reducing the working expenses and increasing the income. The following figures show the receipts as compared with last year:—1882-3, £520 8s. 6d.; 1883-4, £1,433 14s. 5d.; increase, £913 5s. 11d. The Fine Art Exhibition held at Cardiff, from February to May this year, was lighted from your Cardiff station. The light was much appreciated, and the installation was in every way a success. As fast as possible the old yearly contracts are being terminated, and all lights charged for by the hour instead. The number of lamps in use is as under:—Bristol, arc 28; Cardiff, arc 34; total, 62. Bristol, incandescent 334; Cardiff, incandescent 64; total 398. These numbers will probably be increased during the coming winter. The plant is in good working order, and fully capable of the work required of it. That a portable plant, consisting of engine, boiler and dynamo, and five 2,000 candle-power arc lamps has recently been purchased. This plant is especially adapted for the lighting of fancy fairs, bazaars, *fêtes*, flower shows, public meetings, &c., and is often the means of introducing the light into a district, and thus making it known. Shareholders hearing of local bazaars, *fêtes*, &c., would materially assist the Company by sending early particulars to the office, so that the Company may have an opportunity of tendering for the lighting. Steps have been taken to canvass one or two likely towns, with a view of testing their suitability for erecting lighting stations, but so far no town has held out a sufficient promise of support to warrant the erection of plant. That in the early part of the present year negotiations were opened with the Anglo-American Brush Electric Light Corporation, which resulted in the sale to them by your Company of the right to light by electricity railway trains in your district, together with the right to erect in your district any plant that may be necessary to carry out such lighting. In exchange for this concession the corporation surrendered £5,750 in fully paid shares in your Company, thus reducing your capital account by that amount. That in looking forward to another year's working, whilst a large business must not be expected, your Directors trust by exercising prudence and economy to be able to carry on the Company for a small outlay, in the belief that for those electric lighting companies which can live through the present period of depression there remains a good prospect of success in the future. One of the chief difficulties in the way of profitable business—the fact that so many companies were ready to undertake work at a loss—is now rapidly disappearing, several such companies having gone into liquidation during the year. This reduces the competition and increases the chances of obtaining profitable work. The result of this year's trading shows a loss of £537 19s. 11d.; to this must be added £529 5s. 3d. written off for depreciation of plant, making a total loss of £1,067 5s. 2d. for the year. Deducting this and the law charges incurred during the year from the £5,750 received from the Anglo-American Brush Electric Light Corporation, there remains a profit of £4,073 16s. 11d., which it is proposed to write off the shares to be issued to the Devon and Cornwall liquidator. The balance sheet has been drawn accordingly. Under the Articles of Association one of your Directors, Mr. J. B. Braithwaite, jun., retires by rotation, and, being eligible, offers himself for re-election. The auditors, Messrs. Turquand, Young, and Co., also retire under the Articles of Association, and, being eligible, offer themselves for re-election. The new certificates will be ready in exchange for the old certificates on the re-opening of the transfer books on 11th October, and shareholders will oblige by sending in their old certificates for exchange as early as possible after this date.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Oct. 1.		Business Done Week Ending Oct. 1. Highest.	Lowest.
Anglo-American	31½,	82	82	31¾
Do. Preferred	55¾,	56¼	56⅛	55¾
Do. Deferred	7,	7¼	7¼	7⅛
Brazilian Submarine	11 1-16,	11 3-16	11 5-16	11¼
Cuba	11,	11½	11	—
Do. Preference	17,	18	—	—
Direct Spanish	3¾,	4¼	—	—
Do. Preference	15,	15½	14⅞	—
Direct United States Cable	10,	10¼	10⅛	10 1-16
Eastern Telegraph	11 9-16,	11 11-16	11¾	11 9-16
Do. 6 per Cent. Preference	13½,	13¾	13¾	13⅝
Do. 5 per Cent. Debentures, 1899	104,	107	—	—
Eastern Extension	12 1-16,	12 3-16	12 1-16	11⅞
German Union	9⅞,	10⅛	10	—
Globe Telegraph and Trust	7,	7⅛	7⅛	7
Do. Preference	12 11-16,	12 13-16	12⅞	12⅝
Great Northern	13½,	13¾	13 13-16	—
Indo-European	32,	33	—	—
Reuter's	8,	8½	8	—
Submarine	170,	180	175½	—
West India and Panama	⅞,	1	15-16	⅞
Do. 1st Preference	7½,	7¾	—	—
Western Brazilian	6⅝,	6⅞	7	6⅞
Western Union 7 per Cent. 1st Mortgage	123,	125	—	—
Do. 6 per Cent. Sterling Bonds	100,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	¼,	⅜	5-16	—
Oriental	3-16,	5-16	¼	—
United Telephone	13⅛,	13⅜	14	13 3-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1¼,	1⅜	1 1-16	—
Do. (fully paid)	2¼,	2¾	—	—
Hammond Light (£3 15s. paid)	⅛,	⅜	¼	—
Swan	—	—	—	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	33,	33½	33⅜	33¼
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23½	23⅜

UNIVERSITY COLLEGE, BRISTOL.

In the Department of Experimental Physics at this College LECTURES and CLASSES arranged progressively are given throughout the Session, and Instruction is given in the Physical and Electrical Laboratory. In the Engineering Department Special Courses have been arranged for Students studying for the profession of Engineering who wish to include in their professional training some knowledge of Electricity and its technical applications, especially with regard to Electric Lighting and Transmission of Power, Telephones and Telephonic Systems, Telegraphy, Electro Plating, &c.

UNIVERSITY LECTURES at POPULAR PRICES.—Courses of WEEKLY LECTURES, accompanied by CLASS TEACHING, will be held during the Coming Session (October-December, 1884), in connection with the London Society for the Extension of University Teaching, as under:—ELECTRICITY, at Highbury; SOME PHYSICAL PROPERTIES OF AIR AND WATER, at Whitechapel. Lecturer, J. W. WAGHORN, D.Sc., R.N., Instructor in Physics at the Royal Naval College, Greenwich. For prospectuses and all information apply to the Secretary, University Extension, 22, Albemarle-street, W.

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NOTES.

TELEGRAMS FOR TASMANIA.—The cable between Australia and Tasmania is now repaired.

THE TELEGRAPH IN BOKHARA.—From Vienna it is reported that telegraphic communication has been completed to Bokhara.

TELEGRAMS FOR CHINA AND JAPAN.—The cables between Hong Kong and Saigon and between Haiphong and Hong Kong are interrupted.

UNIFORM MERIDIAN.—The International Prime Meridian Conference, which has been sitting at Washington for about a week, has adjourned without coming to a decision on the question at issue.

THE MACKAY-BENNETT CABLE. — On Wednesday the "Faraday" completed the work of laying the second Mackay-Bennett cable, when the shore end was made fast at Dover, New Hampshire.

THE MILITARY TELEGRAPH CORPS.—The transport ss. "Deccan," carrying the final detachment of telegraphists belonging to the Postal Telegraph Service and Royal Engineers, arrived at Alexandria on Tuesday, 7th inst.

EASTERN EXTENSION TELEGRAPH COMPANY.—The traffic receipts of this company, including all subsidies, for the month of September amounted to £41,590, and to £39,576 in the corresponding period of 1883, being an increase of £2,014.

THE TELEPHONE IN THE DOCKYARDS.—The Admiralty have directed telephonic communication to be established at Sheerness Dockyard between the offices of the captain-superintendent and the chief constructor and the various workshops.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 3rd October, were £2,779, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

ELECTRICAL COMPANIES IN BRUSSELS.—It is rumoured that a project is on foot for an amalgamation of two leading electrical companies under the style of "Syndicat d'Electricité," with the material support of one of the Belgian banking companies.

FIRE TELEGRAPH.—At the usual weekly meeting of the Oldham Board of Guardians the seal was affixed to a contract between the Postmaster-General and the Board for the maintenance of telegraphic communication between the workhouse and the fire brigade station.

ANTWERP EXHIBITION.—On account of the numerous applications for space, the last date for receiving exhibits has been deferred to the 20th inst. A much larger covered area than that originally contemplated will be required, and the works are being pushed forward with spirit.

FROM AMERICA.—A new telephone instrument has been invented by which the crying of a baby may be heard at the distance of a hundred miles, and bachelors are beginning to consider whether it is better to marry or move out of the country.—*Cincinnati Merchant Traveller.*

ELECTRIC LIGHT IN BRUSSELS.—The temporary lighting of the Grand' Place, Brussels, by two 10,000 candle Jaspar lamps, mounted on masts 62ft. high, is most successful. The fine old Hôtel de Ville and the façades of the ancient houses of the various guilds appear to great advantage in the artificial moonlight.

APPOINTMENT.—With a view to the better administration of the telegraph arrangements in Egypt Her Majesty's Government have, at the nomination of the Postmaster-General, appointed Mr. A. Otway, one of the assistant-superintendents at the London Central Telegraph Office, to be Superintendent of the Telegraphs at Cairo.

ELECTRIC LIGHT ON THE CALEDONIAN RAILWAY WORKS.—A party of Royal Engineer officers lately visited the Airdrie branches in construction of the Caledonian Company's new Lanarkshire Extension. The excavation is being effected by steam navvies, which work, with the aid of the electric light, by night as well as by day.

THE TELEPHONE AT MONTE VIDEO.—The Uruguayan Telephonica Compagnia, founded 1st February of the present year, numbered 632 subscribers on 1st July, notwithstanding the competition of the River Plate Telephone Company, with 450 subscribers, which had been in existence a long time previously. The former company use Blake-Bell, and the latter Gower-Bell instruments.

GLOBE TELEPHONE SHARES.—In consequence of an advertisement, headed as above, issued in the newspapers by Messrs. W. Gutteridge and Co., the secretary of the United Telephone Company (Limited) writes as follows to the *Daily Telegraph*:—"I am instructed to inform you that the statements therein contained concerning this company's arrangements with the Globe Company are erroneous, and calculated to mislead the public."

LA LUMIERE ELECTRIQUE.—Dr. Cornelius Herz, who was at one time connected with the Mount Sinai Hospital, New York, is very prominently connected with electrical enterprise in Europe. He is editor and proprietor of *La Lumière Electrique*, Paris. He is French by birth, but emigrated to America at a very early age. He returned to France in 1870, to organise the telegraphic department under Gambetta.—*Jewish World.*

THE ELECTRIC LIGHT IN DUBLIN.—A *fête* has been held in Dublin at which a number of Weston arc lamps have been used. These gave so much satisfaction that another *fête* was given, at which a still larger number of the lamps were employed. The lights were very brilliant, and were much admired by a numerous and critical assemblage. The arrangements were under the management of the Maxim-Weston Company, who supplied the whole of the plant.

ELECTRIC LIGHT AT ANTWERP.—Unlike the telephone, the electric light has not been taken up to any extent at Antwerp. The large goods station is thus illuminated, and the proprietor of a café adopts it as an attraction, taking his power from a neighbouring manufacturer's engine. There is here a fine field for a company who would generate current at a central station and supply it to subscribers for electric lighting, as the Hammond Company does at Middlesbrough.

EASTERN TELEGRAPH COMPANY.—This company announces the payment of a dividend of 3s. per share on the preference shares for the quarter ending 30th September, 1884, and an interim dividend of 2s. 6d. per share on the ordinary shares, in respect of profits for the quarter ended 30th June, 1884. The register of transfers will be closed from the 8th to the 15th instant, both days inclusive. The traffic receipts of this company for the month of September amounted to £50,913, and to £42,778 in the corresponding period of 1883.

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THE ELECTRIC LIGHT AT HEBBURN.—At the last monthly meeting of the Hebburn Local Board, Mr. C. F. Forster presiding, a discussion took place on the price paid for gas by the ratepayers of Hebburn. It was resolved that the chairman and Messrs. Tennant and Richardson be appointed a deputation to wait upon the Gas Company with a view to have the scale of charges reduced, and that Swan and Company be communicated with for the purpose of obtaining information as to the probable cost of lighting Hebburn by electricity.

ELECTRIC TRAMCARS IN BRUSSELS.—We assisted at some remarkably successful trials of electro-locomotive tramcars on the Brussels boulevards, and duly recorded the results. We also saw a contract that had been made between the electric company and the tramway company for working the Rue de la Loi line by accumulators for six months at the price of horse traction. A start was to have been made on 1st July. This was altered to 1st August, then to 15th September. In fact, the electric working was, like shows at a fair, always "going to begin." Now, however, the trials are suspended, and we do not even hear of a prospective date being named.

THE TELEPHONE IN FRANCE.—We learn from an article bearing this title in the *Bulletin de la Compagnie Internationale des Téléphones* that there is a question of the Société Générale des Téléphones granting a discount of 5 per cent. off subscriptions when paid for three years in advance. Further, that four persons occupying the same block of buildings may unite in a subscription of 300f. (£12) per annum. Increased facilities in provincial centres are contemplated. On the 2nd inst. the company had 5,417 subscribers, or 655 more than at the same time last year. Contrary to its original intention, the council of management has decided to take part in the Antwerp Exhibition of next year.

THE ELECTRIC LIGHTING ACT.—The electric lighting interest have, says the *Pall Mall Gazette*, commenced proceedings against the Electric Lighting-Act, which is now so generally regarded as a failure. At a recent meeting of the Dynamicable Society it was resolved to form a committee, including the names of most of the prominent electricians of the day, to draw up a report setting forth the errors in the evidence given by the "expert" witnesses before the Parliamentary Committee of 1882; and to organise a movement for the repeal of the impossible clauses in the Act of that year. More freedom to develop our industry according to the light of our own practical experience is the demand of the electricians.

PERSONAL.—We understand that Mr. J. Kenneth D. Mackenzie, lately engineer to the National Company for the Distribution of Electricity by Secondary Generators (Limited), and for some time practising on his own account at 25, Queen Anne's-gate, Westminster, has just entered into partnership with the Honorable Reginald Brougham, late engineer to the British Electric Light Company (Limited), and that they will commence business as engineers and electricians. We believe that Messrs. Mackenzie and Brougham do not intend to confine themselves to electricity alone, Mr. Brougham having practised for some years as a civil engineer, but will undertake any work connected with the principal branches of engineering. Their offices are at 15, Great George street, Westminster, S.W.

HEALTH AND ELECTRIC LIGHTING.—Mr. J. Angelo Fahie, C.E., member of the Society of Telegraph Engineers and Electricians, read a paper, on 3rd inst., before the Engineers and Architecture Section of the Sanitary Congress, Dublin (Mr. C. P. Cotton, M.I.C.E., in the chair), on "Electric Lighting considered from a Sanitary Point of View." The light afforded by electricity, he said, was far superior to all other illuminants in the fulfilment of health conditions. An ordinary gas burner deprived 17 cubic feet of air of its oxygen in an hour, and furthermore contaminated it with poisonous compounds. Electric lighting by incandescence consumed no oxygen, gave off no carbonic acid, or other compounds, and consequently did not at all vitiate the atmosphere. A full report of this paper, and the discussion that ensued, will appear in our next issue.

TELEGRAPH CLERKS' GRIEVANCES.—A large meeting of telegraph clerks was held at the Edinburgh Ship Hotel on Saturday last, to consider the reply of the Postmaster-General with reference to their Sunday duty petition. Several letters were read, reporting the progress of the agitation throughout the country. The following resolution was unanimously adopted :—"That this meeting of Edinburgh telegraph clerks records its feeling of regret and disappointment at the unsatisfactory reply received from the Postmaster-General with reference to their Sunday duty petition, and resolves to use every effort to obtain redress of the glaring anomaly in the treatment of provincial telegraph clerks, in so far as they are exceptionally treated by not being paid uniformly with the London clerks for Sunday work." Similar meetings are being organised throughout the country.—*Scotsman*, Oct. 7.

THE TELEPHONE IN BELGIUM.—During the month of September just past no less than 15,064 messages were exchanged by telephone between the subscribers to the telephone companies holding concessions and the telegraph offices which form the points of junction. Of this number 3,342 originated in Brussels, 2,904 in Liége, 2,841 at Antwerp, 2,345 at Ghent, 1,691 at Charleroi, 985 at Louvain, and 956 at Verviers. The whole population of Belgium does not much exceed that of London and its suburbs. It is stated that a definite understanding has been come to between the Belgian Government and the Bell Telephone Company for the working by this company of telephonic communications between towns on the Van Rysselberghe system ; and that a few privileged individuals who have exchanged telephonic messages between Brussels and Antwerp find no greater difficulty than in speaking to any part of the capital.

ELECTRICAL BALLOON PROPULSION.—MM. Tissandier, who were the first to apply electricity to the propulsion of balloons, have, since their ascent of 8th October, 1883, introduced some improvements into their balloon, and especially the rudder. On 26th September last they made a fresh ascent, with a result quite commensurate with their anticipations. Starting from Auteuil, a suburb of Paris, at twenty minutes past four in the afternoon, they made several evolutions in different directions over the city, progressing at one time for more than a quarter of an hour against the wind, in the presence of thousands of spectators. The speed of the wind was about 3 metres a second, and that of the balloon rather higher. With a screw speed of 190 revolutions per minute, an actual power of 1½ horse was obtained, the battery being provided with larger zinc plates than before, and a hotter, more acid, and more concentrated solution of bichromate of potash.

BLACKBURN'S PORTABLE TESTING APPARATUS.—This instrument, of which Messrs. Clark, Muirhead, and Co. are the manufacturers, contains a Wheatstone bridge, resistance coils, galvanometer, and battery, with the necessary keys and connections joined up, for instant use. The dimensions permit of its being carried in the pocket, and it may be used for measuring resistances ranging between ·005 and 2,000 ohms. The arrange-

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ment of the branch coils is the same in principle as in Thomson and Varley's slide resistance box. Eleven coils, with contact pieces, are arranged in series in the base beneath the turntable, the latter carrying two contacts which serve to embrace two of these coils. A wire, having double the resistance of a single coil, is stretched round the edge of the table and joins the two contacts, being, for final adjustment, capable of division at any point by the index arm which carries the battery current. The galvanometer has a resistance of 4 ohms; the needle is astatic, and is suspended by a silk fibre.

THE TELEPHONE AND GUNNERY.—The telephone was used, for the first time in connection with volunteer artillery practice, by the Risca detachment of 1st Worcestershire A.V., at the Nash ranges, Newport, Mon., on Monday week. A 64-pounder was brought up to 2,500 yards from the marking point, and 6,000 yards from the target, but so placed that the detachment working the gun could not see the target. The firing was rather wild at first, but owing to the directions given through a Gower-Bell telephone, with portable lead, consisting of a double cable, as to the effect of each shot, the gun was eventually trained to cover the target. The whole apparatus consists of a cart and limber carrying the 4,000 yards of wire in 500-yard sections for convenience of carriage, the lengths being coupled up by an ingenious joint devised by Mr. G. Wilson, electrical engineer of the Risca Collieries, by whom the whole apparatus has been arranged and supplied. The result was considered by the volunteers, under the command of Col. Cumings, a complete success.

ELECTRIC LIGHT ON THE INNER CIRCLE RAILWAY.—The Inner Circle of the Underground Railway was opened for public traffic on Monday last. The Edison and Swan United Electric Light Company received the order to illuminate the new Cannon-street Station on Saturday week, and the work was commenced last Tuesday. The whole station was completely lighted by the following Monday, including all the booking and other offices. The installation consists of an Edison "L" dynamo, driven by a Marshall portable engine, placed on Dowgate-hill. The number of lamps is 80, about 30 of which will be of 30 to 40 candle-power, according to requirements. The whole of this very rapidly-executed work has been completed in a thorough and substantial manner, all joints being soldered, and all the necessary switches and cut-outs being inserted. The railway company have been willing to pay the cost of lighting this station, which is in a measure experimental, so as to enable them to ascertain the working cost, and what effects can be satisfactorily produced with incandescent lamps, as we understand that they intend, if the results are satisfactory, to light up the remainder of their new stations in a similar manner."

THE BRIGHTON ELECTRIC RAILWAY.—The extension of this line having now been in operation for six months, a few particulars may be interesting as showing the capabilities of a light line of this description. The details of construction have been already described in our columns, and need not therefore be repeated. The car mileage amounts to 15,600 miles, or 100 miles per diem; and the number of passengers in round numbers, to 200,000. These figures would have been increased but for the fact that at certain hours the would-be passengers exceeded the capabilities of the car, which seat 30 persons only. No accident has occurred to either the general public or to passengers by the car. The consumption of gas in the gas engine has been 300,000 cubic feet, or 1½ cubic foot per passenger per mile. The total cost of traction, including interest and depreciation on engine, dynamo, and motor, cost of gas, oil, and attendance, has amounted during that period to 15s. 6d. per day (100 miles run), say 2d. per mile. The car service has only been stopped for one day, through the tyres of the wheels giving out, owing to the heavy pressure of the holiday traffic, when there was no second car available.

UNDERGROUND TELEPHONE WIRES IN EDINBURGH.—We learn that the Streets and Buildings Committee of the Edinburgh Town Council have had under consideration an application by the National Telephone Company for permission to lay underground telephone wires in the city. After deliberation, the committee agreed to recommend that the council sanction the laying of two main lines by way of experiment. The wires are to be enclosed in metal pipes and laid two feet from the surface of the streets, with branch lines at various points on the route, where inspection boxes will be placed. As it is necessary to provide occasional means of communication between the underground pipes and the roofs of adjoining buildings for affording electrical communication with the company's subscribers, it is proposed to convey a cable or bundle of wires from the most conveniently situated box under the footpath to the wall of the building with which it is required to establish communication, and to carry the cable enclosed in a small pipe up the wall of the building to the roof. On the roof will be erected a standard similar to those now used by the company in Edinburgh, to which the cable or bundle of wires will be attached. From the standard, ordinary naked wires will be led to the offices of the subscribers.

CARDEW'S SYSTEM OF DYNAMO WINDING.—This invention consists in an arrangement to enable the same dynamo to be used for working arc, incandescent, or search lights at pleasure. By means of a switch-board placed on the machine, it is possible to so connect up the coils of the magnet fields as to allow of four powerful arc lights being worked simultaneously; or, if four be not required, three, two, or one may be worked in parallel. The arrangement also permits of any of the arc lamps being worked independently of the others. Moreover, by a simple alteration on the switch-board, the machine can be used for working a single powerful hand-regulated search light of 25,000 candles, suitable for naval or military purposes. The same machine will maintain 100 twenty candle-power, sixty-volt Victoria lamps, and, being self-regulating, these lamps may be turned on and off at will in any required number, the speed remaining practically constant. It is also possible to work arc and incandescent lamps in parallel simultaneously. The system is peculiarly applicable to differentially wound lamps; and it is stated that no artificial resistance is required in the circuit of the arc lamps to ensure perfectly steady burning and complete independence of action in the lamps. The machine is the invention of Captain Cardew, R.E., and is supplied by Messrs. Clark, Muirhead, and Co., who are prepared to grant licenses for its use.

ELECTRIC LIGHT ON STEAMERS.—The Great Eastern Company's last new steamer but one, the "Norwich," was fitted with sixty-two Swan incandescent lamps, in opal globes, by Siemens Brothers' northern agent, just sixteen months ago, and they have been maintained ever since by a Gramme 60-light dynamo, driven with rope gear by a Shanks' horizontal engine, without a single hitch due to the electrical portion. There are twelve lamps in the saloon and one in each cabin, besides staircases, &c. When the steamer is running, the special engine takes its steam from the main boilers, but while in port, from the steam-winch boilers, the change being now made without extinguishing the light. The lamps, which

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cost 4s. 6d., are warranted for 1,000 hours, but many of them last three times as long. There is no electrician on board, but the engineer looks after the dynamo and the chief steward superintends the lamps and connections. He testifies to the great cleanliness and convenience as well as saving effected by the electric light, breakage of glasses being no small item with the petroleum lamps formerly used. The "Ipswich" is similarly fitted, but the switches for turning each lamp on or off are placed outside the cabin door instead of inside, a more convenient arrangement. We may add that all the arrangements on board for passengers' comfort are quite on a par with this great progress of adopting the electric light.

The Telephone at Antwerp.—The telephone has entered so thoroughly into commercial life at Antwerp that its suppression would now lead to something like a cessation of business. A local Bell Company started the lines about three years ago, the original subscribers paying only 200f. (£8) per annum, but new subscribers are charged half as much again. For this the company lays the wires, supplies the instruments, and maintains the whole in working order. The police stations and also the leading medical men are put in communication, and the current is on day and night. It may be said that at least one in five of the principal business houses is connected, together with all the leading hotels and cafés. What astonished us was to see the words "teléphone publique" put up at some quite minor *estaminets*, or public houses, and we learnt that the instruments were at the disposal of all and sundry who might call for a glass of beer, as the telephone brings custom to the tap. There are also three telephone offices on the boulevards, whence the public can hold converse with subscribers for the small charge of 50c. (5d.). These offices also serve as tramway stations and ladies' retiring rooms. All the fire brigade stations are of course connected, as also the office of the new water works, owned by an English company. This company has also a private single wire telegraph between its office and the works at Walhaem, twelve miles off, that only cost £300, and seven minutes after the outbreak of a fire the pressure is increased all over the town.

The Atlantic Cables.—It having been reported that both cables of the Western Union Cable Company had met with serious accidents, the *Standard's* correspondent at Penzance telegraphed as follows on Tuesday:—"It has been ascertained so far as actual tests have gone that only one of the cables has been really severed. It was on Friday evening last, at 9 p.m., that communication ceased with one cable, and at four on Saturday morning the second and only remaining cable of this company became inactive. The test which has been applied in respect to the second cable leads those who have made it to imagine that it is not broken, but that the gutta percha is pressing on the wire itself. It is believed that the cables have been thus interrupted eighteen hundred miles from the Land's End, the one that has broken having gone somewhat nearer the English coast than the spot at which the second has been interfered with. It is not credited, however, that icebergs have had anything to do with the matter. It is feared that the Western Union Company will not be in a position to renew operations for several months. An electrician from Messrs. Siemens is expected in Penzance this evening to test the cables, with the view of definitely ascertaining where the accidents have occurred." One of the Mackay cables just laid was also *hors de combat* on Monday. It is thought the Western Union cables will take some time to repair, but the Mackay-Bennett cable can be spliced in a short time, as the "Faraday" is on the spot, and can effect the necessary repairs after laying the section of cable she has now on board.

Electric Light at Deal.—The secretary of the Deal and Walmer Electric Light Company recently addressed a letter to the Deal Town Council, making a second application for permission to lay a cable for electric lighting between Alfred-square, along High-street, to Deal Castle, and adding that one of the principal clerks to the Board of Trade states that the Electric Lighting Act does not render necessary a licence or a provisional order, provided the sanction of the Local Authority be obtained to laying the wires. He enclosed letters from the secretaries of the Brighton, the Hastings, and the Eastbourne Electric Lighting Companies, all of whom stated that they had laid wires without a licence or provisional order. After a long discussion, during which Councillor Ramell stated that if the Council granted permission to lay the wires, M. Jarman, inventor of the Jarman arc lamp, would carry out the work, the following resolution, drawn up by the town clerk, was carried unanimously:—"That provided the directors of the company or some other responsible persons will enter into personal guarantee to be responsible for all the expenses of laying down the cable, making good the pavement to the satisfaction of the surveyor, and the making good of all other damage that may be done either in pavement or to the pipes of the Gas and Water Company, that the Council would permit the application without prejudice to any rights which the Council may think fit to exercise hereafter in regard to a licence, provisional order, or otherwise in connection with such electric lighting, and subject to a proper agreement to be entered into with the town clerk."

Mercurial Electro-Dynamometer.—An abstract in the *Chem. Soc. Jour.* describes M. G. Lippmann's electro-dynamometer as follows:—"A small parallelopipedal chamber filled with mercury and communicating laterally with the two branches of a manometer is supported in the centre of a bobbin of copper wire. The current passes through the wire and thus through the mercury, and the manometer shows a permanent deviation due to the electro-dynamic action exerted on the mercury by the remainder of the circuit. The deviation is strictly proportional to the square of the intensity of the current, and the apparatus can be used to measure alternating currents. All the parts of the apparatus are rigid and immovable with the exception of the mercury, and even in this latter case the points at which the current enters and leaves the mercury have an invariable position with respect to the rest of the apparatus. In consequence of this rigidity the form and sensibility of the apparatus remain perfectly constant. This instrument can be constructed to measure currents in absolute measure, for the pressure, p, indicated by the manometer, is connected with the intensity I, by the formula $p = \frac{C}{E} I_2$, where E is the thickness of the layer of mercury and C is the intensity of the magnetic field produced at the centre of the bobbin by a current of unit intensity. The former is measured directly; the latter is deduced from the dimensions of the bobbin, and increases indefinitely with the number of turns of the copper wire. In the mercurial galvanometer both the numerator and denominator in the expression $\frac{H}{E}$ have a maximum limit."

The Approaching Telegraph Conference.—The following letter has been forwarded to *The Times* by Mr. H. R. Meyer in reference to this subject:—"I beg you will allow me space to remind the commercial community of the fact that early next year a telegraph conference will be held in St. Petersburg, which will possibly pass such new rules as will very seriously affect every firm using submarine cables. For instance, I am given to understand that a strong effort

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is to be made by the cable companies to reduce the limit for code words from ten letters to eight. In effect, I estimate this alteration, if passed, to be equivalent to an increase of 25 per cent. in rates, because the number of words of that length suitable for code ciphers is too limited to allow of a code anything like sufficient to meet business requirements being constructed therewith; consequently, in many cases where one word would now suffice two will then have to be used. I hear also of other proposals, all in the direction of limiting the use of telegraphic codes, and consequently increasing the cost of telegraphing. On the last occasion of a similar conference, although you were good enough to admit my letter in reference to the matter, neither did the various Chambers of Commerce, whose province the subject distinctly belongs to, nor did commercial men do anything until the new rules were passed, and they then found their loud complaints in consequence of the inconvenience they were put to calmly ignored. I would suggest that those interested should move in the matter at once in order to prevent any needless changes in existing regulations affecting the codes now used. Either the commercial interest should be specially represented at the conference, as from its importance it certainly deserves to be, or the Government should be strongly and influentially memorialised to secure instructions being given to the British representative to protect commercial firms from any further annoying changes. What is everybody's business becomes nobody's, to prevent which in this case I am willing to place my services at the disposal of the mercantile community, being well known in connection with the subject, and shall be glad to receive communications and support from all whom it may interest, with a view to combined action before it is too late."

Application of Electricity to Chemical Industry.—The Chemical Society's *Journal* gives the following abstract of a paper by Mr. F. Fischer:—"Lermann recommends the electrolytical deposition of zinc from dilute solutions of the sulphate, by the aid of potassium, sodium, ammonium, strontium, magnesium, or aluminium sulphates, used singly or mixed together. Kiliani states that during the electrolysis of a solution of zinc sulphate of 1·38 sp. gr. (the anodes and cathodes consisted of zinc plates), the evolution of gas is greatest with a weak current, diminishing with an increasing current, and ceasing when 3 mgrms. of zinc are deposited on 1 square centimetre pole surface per minute. The deposits obtained with strong currents were firm. From a 10 per cent. solution the precipitate was obtained in the best form with a current of from 0·4 to 0·2 mgrm. zinc. From weak solutions the zinc was always deposited in a spongy condition, with evolution of much hydrogen. Kiliani concludes that the size of the pole surfaces depends on the intensity of the current and the concentration of the solution. For the extraction of metals from ores Blas and Miest employed a process which depends on the fact that the natural sulphides conduct electricity when they are rolled into plates whilst hot. These plates are then suspended as anodes in a suitable bath. For the separation of zinc from blende the bath consists of zinc sulphate, and the following reaction takes place:—$ZnSO_4 + ZnS = Zn + S + ZnSO_4$. The advantages of this process are—(1) the ores do not require to be roasted; (2) the sulphur is obtained as such; (3) less current energy is required for the decomposition of zinc sulphide. In the case of galena, a bath of lead nitrate is used. Marchese has patented a similar process, the essential difference being the suspension in the depositing tanks of the ores in lumps or small pieces filled into iron baskets. Referring to the electrolytic extraction of copper, the author states that the firm of Siemens and Halske, of Berlin, have five machines C_1, each with 12 baths in action, at the Oker Works; each machine is worked with a water-power of 4e. to 5e. and deposits 1 kilo. copper per cell per hour, *i.e.*, about 300 kilos. per diem. At the North German Refining Works in Hamburg, six Gramme machines (No. 1), and one Wohlwill machine are in operation precipitating 2,500 kilos. of copper daily. Oescher and Mesdach have constructed a Gramme machine according to Wohlwill's instructions, which yields 800 kilos. of copper daily. Hilarion Roux, in Marseilles, works with a No. 1 Gramme machine (5e) connected with 40 baths, having 900 square meters anode surface; the cathodes are only 0·5 mm. thick, and are 5 cm. from the anodes. The machine makes 850 revolutions a minute, consumes 240 kilos. coal per day, and deposits, with 8 volts and 300 amperes, 250 kilos. of refined copper. Keith's process for refining lead is worked by the Electro-Metal Refining Company in New York. The bath consists of lead sulphate dissolved in sodium acetate. Gold, silver, and antimony are retained by the anode. The deposition of aluminum by electrolytic means is discussed by the author. According to Weldon, the cost of preparing alumina from bauxite at Pechiney's Works at Salindres amounts to 9·7 per cent., that of the preparation of double chloride of aluminium and sodium 33·4 per cent., and for the decomposition of the double chloride with metallic sodium 56·9 per cent. of the total expenditure. The manufacture of one kilo. sodium costs about 7s., the largest item being for the costs of the vessels in which the sodium carbonate is heated with powdered charcoal, and which are so rapidly destroyed that their cost stands for one-half the total cost of sodium, and a third of the total cost of aluminium. It is further considered an impossibility to reduce alumina by carbon, for the reactions which occur correspond with the following numbers:—

$$2Al_2O_3 + 3C = 2Al_2 + 3CO_2$$
$$-783,200 + 291,000 = -492,200 \text{ cal.}$$
$$Al_2O_3 + 3C = Al_2 + 3CO.$$
$$-391,600 + 85,770 = -305,830 \text{ cal.}$$
$$Al_2Cl_6 + 3H_2 = Al_2 + 6HCl$$
$$-321,870 + 132,000 = -189,870 \text{ cal.}$$

That in spite of these unfavourable thermo-chemical relations sodium can be formed from sodium carbonate and carbon is explained by Weldon as follows:—When a mixture of sodium carbonate and carbon is heated intensely, some of the sodium oxide becomes dissociated, and the carbon then combines with the oxygen, sodium being liberated. The temperature required for the dissociation of Al_2O_3 is, however, considered to be unattainable on a large scale. The author is of opinion that if this explanation is correct there should be no difficulty in obtaining this dissociation temperature by the aid of the electric furnace. Moreover, the reaction $C + 2H_2O = CO_2 + 2H_2$ corresponds with $= 136,800 + 97,000 = -39,890$ cal., and yet it takes place when steam is passed over lignite coke heated to 300 to 350°, a temperature at which steam could not undergo dissociation; the reaction $ZnO + C = Zn + CO$ yields $-85,430 + 28,590 = -56,840$ cal. If, therefore, heat be supplied by external means, reactions accompanied by the absorption of heat would be possible. For the separation of iron from the solutions of aluminium sulphate, sodium sulphate, &c., Löwig and Co. in Goldschmieden deposit the iron electrolytically. When treating solutions of sulphates the anode is to be of lead. The separation of the iron does not take place unless the production of oxygen at the anode can be almost entirely prevented. This is effected either by using an anode with a large surface, or by causing as much resistance as possible to be offered to the passage of the current at the anode."

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ELECTRIC LIGHT AT THE CRITERION THEATRE.

Visitors to the Criterion Theatre during the hot weather must have experienced to the full one of the many advantages the electric light possesses over gas. Mr. Wyndham paid a deserved tribute to its excellence when, in a recent communication to the Press, he stated that the temperature of his theatre was lower than that of the outside air. And when it is remembered that the ceiling of the theatre is some feet below the level of the street, it will be understood how difficult a problem the architect, Mr. Verity, has solved in securing proper ventilation. This difficulty was one of the main reasons for the recent alterations to the building; and it was only by the substitution of the electric light for gas that it could practically be overcome. The result is that this theatre, which was almost unbearable during the hot weather, is now one of the coolest and most charming in London, and is worthy, in respect of the purity and coolness of its atmosphere, of being placed in the same rank as the Savoy.

It has been found at both these theatres that the electric light lends itself to stage effects with much greater facility than gas, and can be used for novel and artistic arrangements in the body of the theatre in situations which are impossible with any other illuminant.

As a case in point we may cite the position of the ring of lights placed round the dome, but one perhaps more noticeable is found in the position of the ceiling lights used in the pit and dress circle. These lights are so recessed into the ceiling itself that it is not necessary to turn them down even when the auditorium is supposed to be in complete darkness; the audience are thus enabled to read their programmes at any part of the performance.

On the stage itself, among other advantages which the electric light brings with it, may be mentioned the substitution of light over-head battens, in place of the cumbersome battens (each weighing several hundredweight) necessary where gas is used. As a consequence of this alteration, the elaborate system of iron extract flues is now dispensed with, and a valuable addition to the height of the stage secured.

The lighting plant, of which we publish a plan, is situated under the new grill room, about 30ft. from the Jermyn-street side of the stage, and adjoining it on the south side is the boiler room, in which three of Messrs. Galloway's boilers are erected. These boilers, two of which will at any time do all the work, are used for various purposes; in fact the electric light is only one of several purposes for which they are employed, some of the others being ventilation, heating, pumping, cooking, &c.

The electric plant proper, as put down by the Edison-Swan Company, consists of two Armington and Sims engines of the high-speed type, the cylinders being 13in. diameter, with 13in. stroke. At present each engine is giving about 83 horse-power, at 250 revolutions, and 75lb. pressure, and as these engines are not yet nearly loaded up to their work, the automatic expansion gear is effecting an extremely early cut off. It is calculated that with the aid of two additional dynamos, for which there is still just enough available space in the present engine room, each of these engines will be able to drive nearly all the lights intended to be used.

The engines drive on to a 4in. steel countershaft, the driving and transmitting pulleys on which are fitted with coned friction clutches, one engine at a time only being used and the other kept slowly revolving as a reserve. These pulleys have been fitted with the Stauffer patent lubricator and grease, which has been found to work very satisfactorily. The friction gear and the runners for tightening the belts are worked by hand wheels on a platform running down the centre of the engine room. A thrust block with hardened centre is fixed at the end of the shaft to contract the end thrust of the main clutch gear. In putting down the shafting provision has been made for the addition of two dynamos at a future time, it being the intention of Messrs. Spiers and Pond to extend the light to their new grill room and other parts when the building is completed.

The dynamos are four Edison 150-light machines, making about 800 revolutions per minute, and running 640 Edison 16 candle-power lamps. All four machines are coupled in multiple arc to one set of mains, and the positive shunt wire of each machine is connected with a general field wire, which insures an equal proportion of current circulating through all the fields and admits of their being simultaneously regulated by the introduction of external resistance. Switches are inserted in the main and field circuits to cut off each machine without intercepting the current from the others, and by a comparatively slight increase of speed any three of the machines could maintain the full load in the event of failure of the fourth.

The mains pass under a corridor to the switch-board at the prompt side of the stage, on which are arranged all the switches, cut-outs, and the regulating apparatus, and from this point each circuit can be separately tested. The switches are all fitted with loose T handles, and can therefore only be manipulated by the attendant in charge. The regulating apparatus consists of ten dials, each subdivided into thirteen segments and controlling the various circuits by means of German silver wire resistances as follows:—

Footlights and proscenium	82 lamps	2·9 ohms	by gradations of	·24	ohm.
Six overhead battens, each	34 „	5· „	„	·41	„
Vertical battens	54 „	3·7 „	„	·3	„
Dome lights ...	59 „	3·3 „	„	·27	„
Auditorium ...	70 „	2·9 „	„	·24	„

The six overhead battens can be regulated separately, or, by a simple mechanical contrivance, can be worked simultaneously, as was shown during the recent performance of *Featherbrain*, in which a daybreak effect had to be produced by gradually increasing all the stage lights from a dull red to full incandescence. The resistance coils are compactly arranged under the stage, in slate boxes, provided with apertures permitting of a free circulation of air.

The whole of the lights on the stage, including the footlights and proscenium lights, numbering 360, are portable, the various connections being made by means of stout flexible cord encased in india rubber tubing. The ends of these cords terminate in copper contact pieces, which can be readily attached to the main wires at a number of specially arranged points both under the stage and in the flies.

The dressing rooms are fitted with double swing brackets, and the corridors, refreshment rooms, crush room and vestibules with handsome brass chandeliers and brackets.

Since the completion of the above work by the Edison and Swan Company, a second contract has been made and completed by them for Messrs. Spiers and Pond for the extension of the light to the east room in the restaurant, consisting entirely of portable table lamps. These lamps are connected in a simple manner with either side of the table at will, and the tables themselves may be detached and moved to almost any part of the room, and reconnected by pins with spring contacts let in flush with the carpet, the only visible connection being a short length of silk covered flexible cord passing over the table cloths to the lamp. Each lamp circuit has a fusible cut-out inserted. This adaptation has been found to add much to the comfort and beauty of the room.

The total number of lamps, as already stated, is about 640, but we are informed that by the beginning of December next twenty-four lights will be added in the west room and about forty in the new grill room, making over 700 lights, and that as the building is completed more will be added, until probably a total of about 1,000 will be employed. Even with this large number it will be necessary to light many places by gas. These facts will give our readers some idea of the elaborate nature and extent of the additions, now fast reaching completion, to the Criterion.

We hear that by special permission of the Edison Swan Company's directors, at the request of Messrs. Spiers and Pond, Mr. J. F. Albright has been retained as their consulting engineer to supervise the working of this recent and important addition to electrical work. We need hardly say he continues to hold his position with the Edison-Swan Company.

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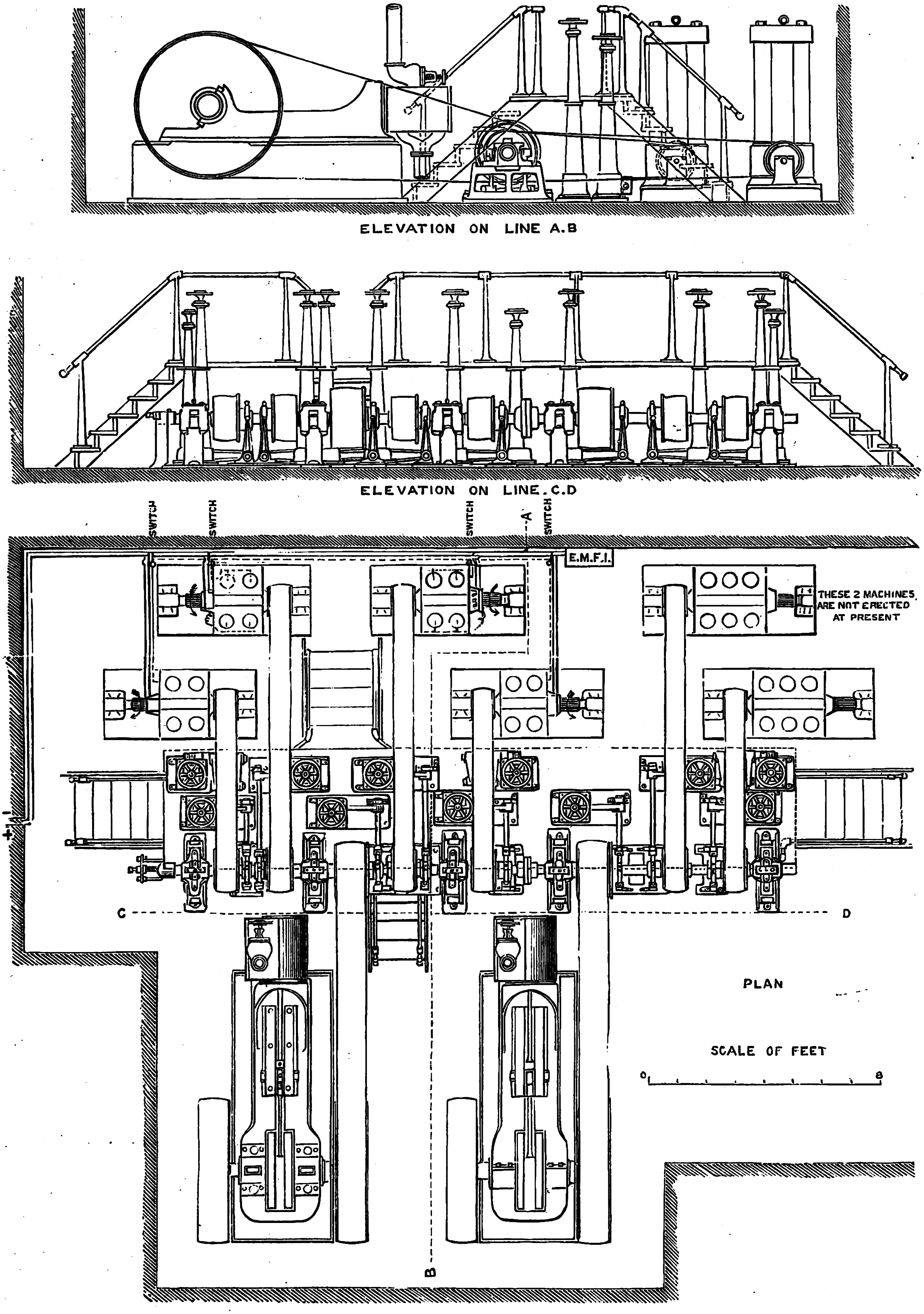

THE ELECTRIC LIGHT AT THE CRITERION. PLAN OF THE INSTALLATION.

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THE BRITISH ASSOCIATION MEETING AT MONTREAL.

On a Gyrostatic Working Model of the Magnetic Compass.*

BY PROFESSOR SIR WILLIAM THOMSON, F.R.S.

In my communication to the British Association at Southport† I explained several methods for overcoming the difficulties which had rendered nugatory, I believe, all previous attempts to realise Foucault's beautiful idea of discovering with perfect definiteness the earth's rotational motion by means of the gyroscope. One of these, which I had actually myself put in practice with partially satisfactory results, was a

Gyrostatic Balance for Measuring the Vertical Component of the Earth's Rotation.—It consisted of one of my gyrostats supported on knife-edges attached to its containing case, with their line perpendicular to the axis of the interior fly-wheel and above the centre of gravity of the fly-wheel and framework by an exceedingly small height, when the framework is held with the axis of the fly-wheel and the line of knife-edges both horizontal, and the knife-edges downwards in proper position for performing their function. The apparatus, when supported on its knife-edges with the fly-wheel not spinning, may be dealt with as the beam of an ordinary balance. Let now the framework bear two small knife-edges, or knife-edged holes, like those of the beam of an ordinary balance, giving bearing-points for weights in a line, cutting the line of the knife-edges as nearly as possible, and of course (unless there is reason to the contrary in the shape of the framework) approximately perpendicular to this line, and, for convenience of putting on and off weights, hang, as in an ordinary balance, two very light pans by hooks on these edges in the usnal way. Now, with the fly-wheel not running, adjust by weights in the pans if necessary, so that the framework rests in equilibrium in a certain marked position with the axis of rotation inclined slightly to the horizontal, in order that the axis of the fly-wheel, whether spinning or at rest, may always slip down so as to press on one and not on the other of the two end plates belonging to its two ends. Now, unhook the pans and take away the gyrostat and spin it; replace it on its knife-edges, hang on the two pans, and find the weight required to balance it in the marked position with the fly-wheel now rotating rapidly. This weight, by an obvious formula which was placed before the Section at Southport, gives an accurate measure of the vertical component of the earth's rotation.‡

Gyrostatic Model of the Dipping Needle.—I also showed at Southport that the gyrostatic balance described above, if modified by fixing the knife-edges, with their line passing as accurately as possible through the centre of gravity of the fly-wheel and framework, and with the faces of the knives so placed that they shall perform their function properly when the axis of the fly-wheel is parallel to the earth's axis of rotation, and the rotation of the fly-wheel in the same direction as the earth's, will act just as does an ordinary magnetic dipping needle; but showing latitude instead of dip, and dipping the south end of the axis downwards instead of the end that is towards the north, as does the magnetic dipping needle. Thus, if the bearing of the knife-edges be placed east and west, the gyrostat will balance with its axis parallel to the earth's axis, and therefore dipping with its south end downwards in northern latitudes and its north end downwards in southern latitudes. If displaced from this position and left to itself, it will oscillate according to precisely the same law as that by which the magnetic needle oscillates. If the bearings be turned round in azimuth, the position of equilibrium will follow the same law as does that of a magnetic dipping needle similarly dealt with. Thus, if the line of knife-edges be north and south, the gyrostat will balance with the axis of the fly-wheel vertical, and if displaced from this position will oscillate still according to the same law; but with directive couple equal to the sine of the latitude into the directive couple experienced when the line of knife-edges is east and west. Thus this piece of apparatus gives us the means of definitely measuring the direction of the earth's rotation, and the angular velocity of the rotation. These experiments will, I believe, be very easily performed, although I have not myself hitherto found time to try them.

Gyrostatic Model of a Magnetic Compass.—At Southport I showed that a gyrostat supported frictionlessly on a fixed vertical axis, with the axis of the fly-wheel horizontal or nearly so, will act just as does the magnetic compass, but with reference to "astronomical north" (that is to say, rotational north) instead of "magnetic north." I also showed a method of mounting a gyrostat so as to leave it free to turn round a truly vertical axis, impeded by so little of frictional influence as not to prevent the realisation of the idea. The method, however, promised to be somewhat troublesome, and I have since found that the object of producing a gyrostatic model of the magnetic compass may, with a very remarkable dynamical modification, be much more simply attained by merely suspending the gyrostat by a very long, fine wire, or even by floating it with sufficient stability on a properly planned floater. To investigate theory of this arrangement let us first suppose a gyrostat, with the axis of its fly-wheel horizontal, to be hung by a very fine wire attached to its framework at a point, as far as can conveniently be arranged for, above the centre of gravity of fly-wheel and framework, and let the upper end of the wire be attached to a torsion head, capable of being turned round a fixed vertical axis, as in a Coulomb's torsion balance. First, for simplicity, let us suppose the earth to be not rotating. The fly-wheel being set into rapid rotation, let the gryostat be hung by the wire, and after being steadied as carefully as possible by hand, let it be left to itself. If it be observed to commence turning azimuthally in either direction, check this motion by the torsion head; that is to say, turn the torsion head gently in a direction opposite to the observed azimuthal motion until this motion ceases. Then do nothing to the torsion head, and observe if a reverse azimuthal motion supervenes. If it does, check this motion also by opposing it by torsion, but more gently than before. Go on until when the torsion head is left untouched the gyrostat remains at rest. The process gone through will have been undistinguishable from what would have had to be performed if, instead of the gyrostat with its rotating fly-wheel, a rigid body of the same weight, but with much greater moment of inertia about the vertical axis, had been in its place. The formula for the augmented moment of inertia is as follows. Denote by—

- W, the whole suspended weight of fly-wheel and framework;
- K, the radius of gyration round the vertical through the centre of gravity of the whole mass regarded for a moment as one rigid body;
- w, the mass of the fly-wheel;
- k, the radius of gyration of the fly-wheel;
- a, the distance of the point of attachment of the wire above the centre of gravity of fly-wheel and framework;
- g, the force of gravity on unit mass;
- ω, the angular velocity of the fly-wheel; the virtual moment of inertia round a vertical axis is

$$W K^2 \left(1 + \frac{w^2 k^4 \omega^2}{W^2 K^2 a g}\right) \quad . \quad . \quad . \quad . \quad (1)$$

The proof is very easy. Here it is. Denote by—

- ϕ, the angle between a fixed vertical plane and the vertical plane containing the axle of the fly-wheel at any time t;
- θ, the angle (supposed to be infinitely small and in the plane of ϕ) at which the line a is inclined to the vertical at time t;
- H, the moment of the torque round the vertical axis exerted by the bearing wire on the suspended fly-wheel and framework.

---

* A paper read at the British Association meeting, Montreal.

† No report of this communication has, so far as I know, hitherto appeared in print.

‡ The formula is $g w = \frac{1}{a} W k^2 \omega \gamma \sin l$,

where w denotes the balancing weight, gw the force of gravity upon it, a the arm on which this force acts, W the weight of the fly-wheel, k its radius of gyration, ω its angular velocity, γ the earth's angular velocity, and l the latitude of the place.

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By the law of generation of moment of momentum round an axis perpendicular to the axis of rotation requisite to turn the axis of rotation with an angular velocity $d\phi/dt$, we have

$$w k^2 \omega \frac{d\phi}{dt} = g W a \theta \quad . \quad . \quad . \quad . \quad . \quad (2)$$

because $gWa\theta$ is the moment of the couple in the vertical plane through the axis by which the angular motion $d\phi/dt$ in the horizontal plane is produced. Again, by the same principle of generation of moment of momentum taken in connection with the elementary principle of acceleration of angular velocity, we have

$$w k^2 \omega \frac{d\theta}{dt} + W K^2 \frac{d^2\phi}{dt^2} = H \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Eliminating θ between these equations we find

$$\left(\frac{w^2 k^4 \omega^2}{g W a} + W K^2\right)\frac{d^2\phi}{dt^2} = H \quad . \quad . \quad . \quad . \quad (4)$$

which proves that the action of H in generating azimuthal motion is the same as it would be if a single rigid body of moment of inertia given by the formula (1), as said above, were substituted for the gyrostat. Now, to realise the gyrostatic model compass, arrange a gyrostat according to the preceding description with a very fine steel bearing wire, not less than 5 or 10 metres long (the longer the better; the loftiest sufficiently sheltered enclosure conveniently available should be chosen for the experiment). Proceed precisely as above to bring the gyrostat to rest by aid of the torsion head, attached to a beam of the roof or other convenient support sharing the earth's actual rotation. Suppose for a moment the locality of the experiment to be either the North or South Pole, the operation to be performed to bring the gyrostat to rest will not be discoverably different from what it was, as we first imagined it when the earth was supposed to be not rotating. The only difference will be that, when the gyrostat hangs at rest, relatively to the earth, θ will have a very small constant value; so small that the inclination of a to the vertical will be quite imperceptible, unless a were made so exceedingly small that the arrangement should give the result, to discover which was the object of the gyrostatic model balance described above; that is to say, to discover the vertical component of the earth's rotation. In reality we have made a as large as we conveniently can; and its inclination to the vertical will therefore be very small, when the moment of the tension of the wire round a horizontal axis perpendicular to the axis of rotation of the fly-wheel is just sufficient to cause the axis of the fly-wheel to turn round with the earth. Let now the locality be anywhere except at the North or South Pole; and now, instead of bringing the gyrostat to rest at random in any position, bring it to rest by successive trials in a position in which, judging by the torsion head and the position of the gyrostat, we see that there is no torsion of the wire. In this position the axis of the gyrostat will be in the north and south line, and, the equilibrium being stable, the direction of rotation of the fly-wheel must be the same as that of the component rotation of the earth round the north and south horizontal line, unless (which is a case to be avoided in practice) the torsional rigidity of the wire is so great as to convert into stability the instability which, with zero torsional rigidity, the rotational influence would produce in respect to the equilibrium of the gyrostat with its axis reversed from the position of gyrostatic stability. It may be remarked, however, that even though the torsional rigidity were so great that there were two stable positions with no twist, the position of gyrostatic unstable equilbrium made stable by torsion would not be that arrived at; the position of stable gyrostatic equilibrium, rendered more stable by torsion, would be the position arrived at, by the natural process of turning the torsion head always in the direction of finding by trial a position of stable equilibrium with the wire untwisted by manipulation of the torsion head. Now, by manipulating the torsion head bring the gyrostat into equilibrium with its axis inclined at any angle, ϕ, to that position in which the bearing wire is untwisted; it will be found that the torque required to balance it in any oblique position will be proportional to the sin ϕ. The chief difficulty in realising this description results from the great augmentation of virtual moment of inertia, represented by the formula (1) above. The paper at present communicated to the Section contains calculations on this subject, which throw light on many of the practical difficulties hitherto felt in any method of carrying out gyrostatic investigation of the earth's rotation, and which have led the author to fall back upon the method described by him at Southport, of which the essential characteristic is to constrain the frame of the gyrostat in such a manner as to leave it just one degree of freedom to move. The paper concludes with the description of a simplified manner of realising this condition for a gyrostatic compass—that is to say, a gyrostat free to rotate about an axis either rigorously or very approximately vertical.

[*For further papers read at the Meeting of the British Association at Montreal see page 497.*]

THE ACCIDENT AT THE HEALTH EXHIBITION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We have had several letters in the dailies this week on the subject of the accident at the Healtheries, each recommending, or in other words advertising, some particular system of electric lighting which is said to be "free from danger."

As long as the multiplication of machines and leads means extra expense there is no doubt but that "high tension" machines will be made and used for arc lighting. Why should not "high tension" machines be made "free from danger?" This may surely be done provided that all parts which require handling, such as brush rockers and binding screw heads, be made of vulcanised fibre, or some other non-conductor. India rubber gloves are all very well, so are rules printed and put up in the vicinity of the machines; but as men get used to the machines they get to look on the danger with contempt, the rules are forgotten, the gloves laid aside, and however careful at first, the men, for convenience sake, handle the machine bare handed. With regard to the use of one glove, in the use of low tension systems high insulation is an absolute necessity, but where high E.M.F. is used it is apt to be neglected. Given a damp day, and bad, or even slightly defective insulation, don't you think it is dangerous to handle a high tension or alternating current machine, even with *one* bare hand? Again, could not some kind of thermal alarm be added to the bearings, so that any rise of temperature would at once indicate itself, and then with no necessity for handling anything but insulated portions of the machine there would be (excepting carelessness and foolhardiness) *absolute safety* to the *employés*? The confidence of the public would be increased, and the progress of electric lighting doubtless accelerated.—Yours, &c., A. GRUNDY.

Law Courts, Oct. 8th, 1884.

DUNDEE TELEPHONY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: You have printed "Curiosity's" inquiry in last week's *Electrician*, and I have pleasure in giving a few facts in regard to the Dundee Telephone Company to satisfy that curiosity.

The company was started in the latter part of 1880. At present it has 330 subscribers on its exchange, besides a few private wires. The length of wire erected is about 280 miles. The instruments in use are chiefly the Gower-Bell, with a few of the Bell-Johnson. In the switch room the boards are of my own design, and are ample and effective. We employ five men, who construct new lines, make replacements, and repair all faults, and I find that number ample.

Financially the company has been a success. The first 16 months' working, at a rental of £10, showed a dividend of nearly 30 per cent., which was paid.

Since then, with a rental of £5 10s., including Government royalty, 5 per cent. per annum has been paid, and a considerable sum has also been set aside for contingencies.

If "Curiosity" wishes any further information he may apply direct to, yours, &c., E. J. B. LOWDON,
Engineer and Electrician to the Dundee and District Telephonic Company.

104, Commercial-street, Dundee, Oct. 6, 1844.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes	485
The Electric Light at the Criterion Theatre. Illustrated	490
British Association:—	
On a Gyrostatic Working Model of the Magnetic Compass. By Professor Sir Wm. Thomson	492
The Seat of the Electromotive Forces in the Voltaic Cell. By Professor O. J. Lodge	497
The Use of Secondary Batteries in Telegraphy. By W. H. Preece	498
Correspondence	493
Dangerous Dynamos	494
The American Association	495
The Philadelphia Exhibition. III.	496
Literature	499
Professor Rowland's Presidential Address at the Philadelphia Congress. (Concluded.)	500
Selected Correspondence	502
Companies' Meetings—	
Great Western Electric Light and Power Company	503
Eastern Extension, Australasia, and China Telegraph Company	504
Companies' Share List	504
Traffic Receipts	504

DANGEROUS DYNAMOS.

It is generally feared that the fatal accident at South Kensington, reported in our last week's issue, may seriously affect the interests of Electric Lighting at this crisis in its history. These apprehensions will of course disappear in due course, as all such apprehensions do; but our first impressions naturally are that the killing of a presumably skilled workman at an exhibition devoted to the preservation of health and life is a most unfortunate business, discreditable to those responsible for the disaster, and a discouragement to the employment of powerful dynamos for any purposes whatsoever. Further reflection will, to be sure, restore confidence both to the public and the profession; but meanwhile we express our firm conviction that the steps taken till now to reassure the non-professional world are far from calculated to attain that object. On the contrary, the letters addressed to the newspapers on the subject, so far from bringing any comfort to the thoughtful reader, will only rouse his suspicions and increase his misgivings. Some of these letters, although quite true as far as they go, are so manifestly designed to "improve the occasion" that the public will attach no weight to them; of the rest we shall speak presently.

In the note appended to our report of the coroner's inquest on the unfortunate man who lost his life by placing his hands on a dynamo at the Healtheries we stated that the one precaution necessary to guard against such accidents was the wearing of india-rubber gloves, and this precaution, we urged, was not merely effectual, but indispensable. When we have said this we have practically exhausted the subject, except to add that the suggestion is not new, but has been adopted in a good many places already, with, of course, the most satisfactory results. The mere fact of protective gloves being provided for the attendants is a better security for their being used, and certainly for more general care in handling than would be insured by any number of verbal warnings. Why this precaution was not taken at the Health Exhibition we are not in a position to say; but we do say this, that if the jury had been composed of professional men the verdict might have been somewhat different. The man had been warned scores of times. Standing by itself this warning does more harm to electric lighting than the death of several workmen would have done. It shows that the fatal risks were well known, and the inference is—a wrong inference, but a quite natural one—that no protection was possible beyond repeating a warning. If a man keeps a vicious dog within reach of the public, it is not sufficient that he stick up a warning notice. In some unguarded moment a passenger unwittingly rouses the animal, and is badly bitten. He naturally protests that the brute ought to have been muzzled or the public fenced off its beat. This is just what the world is saying about dynamos, and this is precisely what the owners of dynamos do not seem at all to realise.

For what do they say in extenuation or deprecation of this mishap? One writer, a high authority on the subject, tells *The Times* that he has never been able to trace any accident to life or health from contact with electric wires provided the electromotive force has not exceeded 600 volts. A doctor might just as well urge in mitigation of hydrophobic panic that he had never traced any ill effects from the bite of a dog whose pulse did not exceed 80. The same writer, with equal forgetfulness of the audience he is addressing, explains that high pressure currents are sometimes used from reasons of economy, but adds that this motive was absent at the Health Exhibition. Thus, then, it seems that the risk of employing dangerous currents is run both by promoters who are obliged to study economy and by those who are not—information which readers of *The Times* may be excused for regarding with much dissatisfaction. These facts, says the unconscious alarmist, are well known to the scientific world; but to the untrained public there is only "one kind of electricity, and they cannot readily understand why it should be dangerous to life in one form and not in another." We think, on the contrary, that the public are not troubling themselves about any such question. They certainly do know without any further training than the electric telegraph and the galvanic machine have afforded that some forms of electricity are harmless; and recent recurring accidents of a fatal kind have demonstrated that some new form of electricity—that, to wit, employed by certain providers of electric light—is highly dangerous. What they really would like to know is why, when dangerous currents are not necessary, they are needlessly employed; and why when they are necessary proper precautions against accident are neglected.

These pertinent questions have not yet been answered, and our object in putting them thus plainly before our professional readers is to get the right answers made public. It would have been better, for example, to have seized this present opportunity for frankly admitting that dangerous currents are commonly used, that such currents (except in special circumstances) need not be used; and where unavoidable the simple and well-known precaution already referred to should be made compulsory. By co-operating with the public in this manner the "scientific world," instead of bewildering them, would win their confidence and sympathy. It is childish and even mischievous to go on repeating the statement that certain currents may be handled with impunity. This irrelevant boast

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has been made a little too often. Probably men like Pink have not infrequently heard it, and have grown less and less cautious in consequence. So long as some currents, by no means the exception, are dangerous, none should be proclaimed harmless, unless we are prepared to proclaim also that none but the harmless should ever be employed. As nobody is inclined to go this length, there should be a general agreement to acknowledge risks and to adopt precautions all round, so that neither through carelessness, ignorance, nor momentary inadvertence may the public again be shocked by a preventable fatality like the one we are now deploring. The employment of electricity will of course never be wholly free from danger; and, as in the case of steam, the more it is used the more accidents will perhaps ensue. But this is no reason for minimising the risks; and in the early stages of electric lighting there are the strongest reasons for multiplying precautions, so as to add nothing to those prejudices which have already retarded its progress very seriously.

THE AMERICAN ASSOCIATION.

The American meeting was held this year in Philadelphia, its birthplace thirty-six years' ago, and it was so timed that those who visited Canada to attend the British Association could go to Philadelphia to attend the American Association; but it was too hurried. Our American friends ought to have made it a week later, for we had to rush away in an apparent hurry, treating with scant courtesy our Canadian hosts. The British Association meeting finished on Wednesday, and on Thursday morning a special train carried away about two hundred to Philadelphia, another hundred journied there leisurely later, but many were prevented from seeing more of Canada, and especially from visiting Toronto and the great North West. An electrical conference under the auspices of the United States Government was also to be held under the presidency of Professor Rowland, and notwithstanding the pressing and warm invitations of those interested, many interesting parties formed to visit the Rocky Mountains and the Yellowstone Park had to be given up. The Britishers were unfortunate enough to bring with them a hot wave. They encountered a temperature that was excessive. Ninety-eight degrees in the shade is something to be experienced, it cannot be described. The air in Philadelphia is so charged with moisture that the perspiration remains on the skin without evaporating away, and the difference between night and day is so small that night is even worse than day. No one who was in Philadelphia in September, 1884, will ever forget it. It is impossible to pursue science with pleasure when you are in the "nineties." Discussion in a furnace is trying. Besides, the accommodation provided for the Sections was not equal to that at Montreal. Some Sections were very close and confined. The American Association is founded on the British Association, but their arrangement of Sections differs. For instance, Section A deals with astronomy and mathematics and Section B with physics, while Section D is the mechanical section. The American Association have no council but a general committee, which does the work of our council. Their general committee does much of the work that is done in the British Association by the sectional committees. The Americans adopt the capital plan of indicating on the programme the probable time that each paper will take to read, and the limitation of the discussion is in the hands of the Section—a power which is very freely exercised. They do not form committees as we do to carry on the work inaugurated at the meeting, and though the meeting at Philadelphia was a highly representative affair, there is reason to believe that the Association has not taken the position in the States that the British Association has in Great Britain. Our visit will probably do them good in this respect.

There is a very peculiar feature of the American Association meeting. The address is given by the outgoing president, and not by the incoming one. The present president is Professor Lesley —a noted geologist—but the address was given by Professor C. A. Young, a noted astronomer, and the retiring president. It was not a general address, but a special one on some pending problems of astronomy—a kind of dip into the future. He dealt with the dimensions and rotations of the earth; he raised the question whether the earth's rotation was uniform, and whether we could rely on the accuracy of the second as the unit of time? Is the position of the earth's axis fixed? He dealt with the moon, her radiant energy and her atmosphere; he does not believe in the existence of Leverrier's Vulcan; he reviewed our knowledge of the features of the different members of the solar system; and dwelt at length on our knowledge of the sun, its constitution and its influences.

The sun is a great ball of intensely heated vapour and gases, clothed outwardly with a coat of dazzling clouds formed by the condensation of the less volatile substances into drops and crystals like rain and snow. Sun spots are dark floating chips or scales thrown up from beneath, like scum in a cauldron. He pronounced himself to be no "sunspotist," except as regards their influence on terrestrial magnetism. He suggested that the prominence of iron in the sun had something to do with this. Solar theories, the hypothesis of the ether comets and meteors, and the stars were finally reviewed, and an exceedingly interesting address was wound up with a few platitudes as to the *cui bono* of all this trouble.

As an electrical meeting the American Association did not shine brightly. The sole paper of interest that was read was by Mr. Hall, who attempted to refute Mr. Shelford Bidwell's criticisms upon his previous paper. He did not accept Mr. Bidwell's thermo-electric theory, and adhered to his original views. The paper led to an extremely interesting discussion, in which Sir William Thomson, Professor Rowland, Silvanus Thompson, G. Forbes, Mr. Preece, and several others took part. It led to Sir William Thomson reading a second paper on the subject, and in fact the "Hall effect" became the feature of the meeting. No fresh facts were brought out, but the theory was discussed, though not elaborated. Bidwell's views were not accepted, though they were not refuted.

Prof. Bell described a proposal to communicate between ship and ship at sea by means of telephones, the circuit being formed partly by wire extending along each ship and trailing out behind by a long insulated wire ending in an earth connection, and partly by the sea between them. He had demonstrated practically the possibility of this by experimenting from boats. In the discussion that followed, Professor Trowbridge described how it was possible to speak across the Atlantic without a wire by having earth plates in Greenland and Patagonia connected by wire, and Mr. Preece explained how communication had actually been made across the Solent through a sea space of six miles and one mile. Professor Silvanus Thompson read two papers, "On a Standard Tangent Galvanometer," and "On the Government of Electric Motors," and General Hazen gave a paper on thunderstorms and their relation to low pressure. Professor Canhart read an interesting paper on the variation of the electromotive force of a Daniell cell, due to the presence of sulphate of zinc, but there was scarcely any other paper of value or novelty.

The meeting would probably have been a very enjoyable one if the weather had been bearable, but as it reminded one

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of Pluto's regions and Dante's Inferno, rather than of our fair earth, it left a search after coolness instead of after knowledge the only possible occupation of the mind. There is some talk of the Association visiting London in 1886. If they come, we can promise them a welcome.

THE PHILADELPHIA EXHIBITION.—III.

(FROM OUR SPECIAL CORRESPONDENT.)

PHILADELPHIA, SEPT. 26.

Notwithstanding the great variety of dynamo machines at the International Electrical Exhibition, there are very few that present points of construction with which the readers of *The Electrician* are not familiar. At the risk of repeating some known facts, I shall describe a few that strike me as novel. The usual form of the Edison dynamo has two or three pillars forming the cores of magnet coils. At the Electrical Conference it was declared that the inductive action of these adjacent coils weakened the magnet, the current reacting upon itself. A suggested improvement was the construction of electro-magnets of equal weight of metal, but with the cores in one piece of elliptical instead of round section. Noticing that some of Edison's new machines (and especially the smaller sizes) were made in this way, I asked him whether the change had been made to prevent this inductive action. He said that there was no such action; that as a matter of fact the more pillars or sections in the field magnet the better, and that the only reason for the change was that the single form was easier and cheaper to construct. In proof of his belief in this theory he pointed out that the very latest machines of the larger size (from 400 to 1,200 lights capacity) were made in the old form.

"Jumbo," his great dynamo of 1,200 light capacity, has a new feature in the armature. Instead of being wound with wire in the usual fashion, longitudinal bars of copper are used, connected together as coils would be by copper discs insulated from each other by mica. Air spaces between the bars (which are ¾in. by ½in. in section) help to keep the armature cool.

He has another form of dynamo which may be used for electro-plating, but it is, I think, merely an experimental machine. It is called the "disc dynamo," and is based upon a machine described by Arago. Instead of revolving a solid disc of copper before the poles of a magnet Edison has cut up the disc into insulated sections, the electromotive force being increased in proportion to the number of sections used. In construction four electro-magnets are laid horizontally, so that the disc revolving between them shall pass between the four pairs of poles. The disc is built up of radial sections insulated from each other, and carried out to the commutator, which is of the ordinary construction. Opposite pairs of the radial sections are connected by insulated bands of copper passing around the circumference of the disc. The faces of this disc or wheel, with its tyre of insulated copper bands, are closely hugged by the poles of the electro-magnet. The disc is about one inch thick, and the tyre probably half an inch wider. The machine is said by Edison to be very efficient, and he says that he can modify the principle to make it effective for electric lighting. He is, however, an exceedingly sanguine man, and sometimes, I think, invents things to show his ability to overcome difficulties rather than follow other inventors in easier ways.

Another strange dynamo reviving an old principle has just been entered at the Exhibition. It is called the pipe dynamo, is used for electro-plating, and has no commutator. It is a commercial application of one of Faraday's earliest experiments, and nothing is yet known of its efficiency. It is a difficult matter to make its method of construction plain without diagrams, but I will try to do so. Two copper cylinders, each about four feet long, four inches in diameter, and half an inch thick, are mounted so as to revolve horizontally parallel to each other, and at a distance apart of, say, eighteen inches. Through each of these cylinders passes an iron bar fixed in position, and these two bars are connected at each end by yokes wrapped with many turns of copper ribbon, the equivalent of coils. The revolving copper cylinders are also enclosed by fixed iron cylinders connected by yokes, wound, like the yokes of the bar, with copper ribbon. These coils are in a shunt circuit. The bars and the enclosing iron cylinders or "pipes" are poles of the magnets between which, in an extended magnetic field, the copper conductor revolves. The current is taken from these cylinders by brushes as from a commutator, but there is, of course, no sparking. I cannot explain the connections, as they are hidden from view, and there is no explanatory diagram—in fact, the exhibit has come in so late that it is not even mentioned in the catalogue.

A dynamo machine with which readers of *The Electrician* are probably familiar is doing remarkable work at the Exhibition. It is Ball's "unipolar dynamo," and came in for a good share of ridicule at the Conference of Electricians. Two Gramme rings are mounted upon a single shaft. Each revolves before *one* pole of a magnet. As the two armatures are on the same shaft, the poles are not opposite each other, but one is above and the other below the armatures, and they are a foot or more apart horizontally. Although some electricians undertook to show that theoretically this was a bad arrangement, the inventor seems to be content with the proof that comes of eating his pudding. I believe electric light companies ordinarily promise one arc light per horse-power. But the Ball unipolar machine is actually engaged in furnishing 17 arc lights from five horse-power transmitted through a 1in. belt.

Nearly all the arc light companies are now introducing incandescent lights, and Edison, in self defence, though he does not believe in arc lighting, is about to introduce this form for the accommodation of his customers who want both systems. The Brush Company have just made a very efficient low tension machine for incandescent lighting with the Swan light. Its secondary batteries used with the same lights are apparently a failure—at least, they have very little to say about them, and have made this new machine, which would seemingly be unnecessary if the storage batteries were to be used.

The Thompson-Houston Company has also begun to introduce incandescent light plants of its own manufacture. It formerly supplied the Edison plant to customers who wanted both kinds. There are besides a number of new incandescent light companies, which make their first appearance at the Exhibition.

The Weston Company has a new and very beautiful carbon filament for their lamps, which is said to be of exceptional long life. As prepared, it is cut into a wave-like loop, and when made incandescent presents a crimped appearance. It is called tamidull, and is prepared from pyroxilline (gun cotton). By treatment with a reducing agent a base is left of homogeneous cellulose, which is carbonised in the usual way. The Weston Company adds to the interest taken in the lamps by showing the whole process of manufacture with samples of the parts in all the various stages of preparation.

The attendance at the Exhibition is increasing daily, and there is talk of extending the time of the Exhibition. There is one exhibit not yet shown, if you can understand such a paradox. All that one can see is a large case covered with muslin, and a placard which states that underneath there is a full display of Daniel Drawbaugh's telephones, not to be shown until after the close of arguments in the great telephone suit now before one of the United States Courts in New York. The Bell Telephone Company sued the People's Telephone Company for infringement of patent rights. The defence is that General Drawbaugh invented the telephone years before Bell began his experiments, and that the latter's patents are therefore void. The case engages some of the greatest lawyers in the country. There are 10,000 printed pages of testimony, and it is as conflicting and curious as that brought forth in the Tichborne trial. Another exhibitor of telephones claims priority of invention over Drawbaugh himself. This is Antonio Meucci, who certainly has a patent twenty years old for a "speaking telegraph." But this and other telephone matters I must leave for a future letter, when, perhaps, I may be able to give more particulars of the great telephone suit.

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THE BRITISH ASSOCIATION MEETING AT MONTREAL.

The Seat of the Electromotive Forces in the Voltaic Cell.*

I. ORTHODOX STATEMENTS BELIEVED BY PROFESSOR O. J. LODGE TO BE TRUE IN THE FORM HERE SET DOWN.

A.—Volta.

1. Two metals in contact ordinarily acquire opposite charges; for instance, clean zinc receives a positive charge by contact with copper, of such a magnitude as would be otherwise produced under the same circumstances by an E.M.F. of about ·8 volt.

2. This apparent contact E.M.F. or "Volta force" is independent of all other *metallic* contacts wheresoever arranged, hence the metals can be arranged in a numerical series such that the "contact force" of any two is equal to the difference of the numbers attached to them, whether the contact be direct or through intermediate metals. But whether this series changes when the atmosphere, or medium surrounding the metal, changes is an open question; on the one side are experiments of De la Rive, Brown, Schultze-Berge; on the other side of Pfaff, Pellat, Von Zahn. It certainly changes when the free metallic surfaces are oxidised or otherwise dirty. And in general this "Volta force" is very dependent on all non-metallic contacts.

3. In a closed chain of any substances whatever, the resultant E.M.F. is the algebraic sum of the Volta forces measured electro-statically in air for every junction in the chain, neglecting magnetic or impressed E.M.F. [Verified most completely by Ayrton and Perry.]

B.—Thomson.

4. The E.M.F. in any closed circuit is equal to the energy conferred on unit electricity as it flows round it.

[Neglect magnetic or impressed E.M.F. in what follows.]

5. At the junction of two metals any energy conferred on, or withdrawn from, the current, must be in the form of heat. At the junction of any substance with an electrolyte, energy may be conveyed to or from the current at the expense of chemical action as well as of heat.

6. In a circuit of uniform temperature; if metallic, the sum of the E.M.F. is zero by the second law of thermo-dynamics; if partly electrolytic, the sum of the E.M.F. is equal to the sum of the energies of chemical action going on per unit current per second.

7. In any closed conducting circuit the total intrinsic E.M.F. is equal to the sum of the chemical actions going on per unit electricity conveyed ($\Sigma . J \theta \epsilon$), diminished by the energy expended in algebraically generating reversible heat.

8. The locality of any E.M.F. may be detected, and its amount measured, by observing the reversible heat or other form of energy there produced or absorbed per unit current per second. [This is held by Maxwell but possibly not by Thomson, though its establishment is due to him.]

II. STATEMENTS BELIEVED BY PROFESSOR O. J. LODGE TO BE FALSE, THOUGH ORTHODOX.

9. Two metals in air or water or dilute acid, but not in contact, are practically at the same potential. [Sir Wm. Thomson, Clifton, Pellat.]

10. Two metals in contact are at seriously different potentials (*i.e.*, differences of potential greater than such milli-volts as are concerned in thermo-electricity). [This is held by nearly everybody.]

11. The contact force between a metal and a dielectric, or between a metal and an electrolyte, is small. [Ayrton and Perry, Clifton, Pellat, and probably Sir Wm. Thomson.]

III. STATEMENTS BELIEVED BY PROFESSOR O. J. LODGE TO BE TRUE, THOUGH NOT ORTHODOX.

12. A substance immersed in any medium tending to act upon it chemically will (unless it is actually attacked) be at a different potential to the medium in contact with it, positive if the active element in the medium is electro-positive, negative if the active element is electro-negative.

13. The above difference of potential can be calculated approximately from the potential energy of combination between the substance and the medium, the energy being measured by compelling the combination to occur and observing the heat produced per amount of substance corresponding to one unity of electricity.

14. In addition to this contact force, due to potential chemical action or chemical strain, there is another which is independent of chemical properties, but which seems to be greatest for badly conducting solids, and which is in every case superposed upon the former contact force, the two being observed together and called the Volta effect. Very little is known about this latter force except in the case of metals; and in these it varies with temperature, and is small. In the case of non-metals it is often much larger than the chemical contact force.

15. The total contact force at any junction can be experimentally determined by measuring the reversible energy developed or absorbed there per unit quantity of electricity conveyed across the junction. [Practical difficulties, caused by irreversible disturbances, being supposed overcome.]

16. In a chain of any substances whatever, the resultant E.M.F. between any two points is equal to the sum of the true contact forces acting across every section of the chain between the given points (neglecting magnetic or impressed forces).

17. In a closed chain the sum of the Volta forces, measured electro-statically in any (the same) medium, is equal to the sum of the true contact forces, whether each individual Volta force be equal to each individual true force or not.

18. Wherever a current flows across a seat of E.M.F. there it must gain or lose energy at a rate numerically equal to the E.M.F. multiplied by the strength of the current.

Development of the above and special application to metals.

19. A metal is not at the potential of the air touching it, but is always slightly below that potential by an amount roughly proportional to its heat of combustion, and calculable, at any rate approximately, from it. For instance, clean zinc is probably about 1·8 volt below the air, copper about ·8 volt below, and so on. If an ordinary oxidising medium be substituted for air in the above statement it makes but little difference.

20. Two metals put into contact reduce each other instantly to practically the same potential; and consequently the most oxidisable one receives from the other a positive charge, the effect of which can be observed electro-statically.

21. There is a slight true contact force at the junction of two metals which prevents their reduction to *exactly* the same potential, but the outstanding difference is small and varies with temperature. It can be measured thermo-electrically by the Peltier effect, but in no other known way. It is probably entirely independent of surrounding media, metallic or otherwise.

22. If two metals are in contact, the potential of the medium surrounding them is no longer uniform; if a dielectric it is in a state of strain, if an electrolyte it conveys a current.

23. In the former case the major part of the total difference of potential is related closely to the difference of the potential energies of combination, and is approximately calculable therefrom. In the latter case the total E.M.F. is calculable accurately from the energy of the chemical process going on, minus or plus the energies concerned in reversible heat effects.

24. There are two distinct and independent kinds of series in which the metals (and possibly all solids) can be placed; one kind depends on the dielectric or electrolytic medium in which the bodies are immersed, the other kind depends on temperature. The one is something like the Volta series, but it is really the Volta series minus the Peltier; the other is the Peltier. To reckon up the total E.M.F. of a circuit we may take differences of numbers from each series and add them together.

* A paper read at the British Association meeting, Montreal.

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IV.—Brief Summary of the Argument.

25. Wherever a current gains or loses energy, *there* must be a seat of E.M.F.; and conversely, wherever there is a seat of E.M.F. a current must lose or gain energy in passing it.

26. A current gains no energy in crossing from copper to zinc, hence there is no appreciable E.M.F. there.

27. When a current flows from zinc to acid, the energy of the combination which occurs is by no means accounted for by the heat there generated, and the balance is gained by the current; hence at a zinc-acid junction there must be a considerable E.M.F. (say at a maximum 2·3 volts).

28. A piece of zinc immersed in acid is therefore at a lower potential than the acid, though how much lower it is impossible to say, because no actual chemical action occurs. [If chemical action does occur it is due to impurities, or at any rate to local currents, and is of the nature of a disturbance.]

29. A piece of zinc, half in air and half in water or acid, causes no great difference of potential between the air and the water (Thomson, Clifton, Ayrton and Perry, &c.), consequently air must behave much like water.

30. If the air were not slightly positive to the water, as it is (Hankel), it might mean that the potential energy of combination of air with zinc is slightly greater than that of water, or it might represent a difference in the thermo-electric contact forces between zinc and air, and zinc and water, or it might depend on a contact force between air and water. [If such a contact force between air and water exists, it is obviously of great importance in the theory of atmospheric electricity, for the slow sinking of mist globules through the air would render them electrical.]

31. Condenser methods of investigating contact force no more avoid the necessity for unknown contacts than do straightforward electrometer or galvanometer methods; the circuit is completed by air in the one case and by metal in the other, and the E.M.F. of an air contact is more hopelessly unknown than that of a metal contact.

32. All electrostatic determinations of contact force are really determinations of the sum of at least three such forces, none of which are knowable separately by this means.

33. The only direct way of investigating contact force is by the Peltier effect or its analogues. [Maxwell.]

34. Zinc and copper in contact are oppositely charged, but are not at very different potentials; they were at different potentials before contact, but the contact has nearly equalised them.

Certain portions of these statements which may appear wildly hypothetical, such as 13, are to be justified by figures. The justification is not complete, for lead and iron are untractable, but it does not affect the main position.

The Use of Secondary Batteries in Telegraphy.*

BY W. H. PREECE, F.R.S.

About the middle of last year a series of experiments with secondary batteries was commenced on some of the telegraphic circuits, terminating at the General Post Office, London, and their satisfactory behaviour during twelve months' trial leads me to bring this subject before this section.

Dynamo-electric machines are regularly employed for signalling purposes in the United States. I think, therefore, before detailing the results of the experiments with secondary batteries in England it would be advisable to mention the experiments made with such machines there also. So long ago as the year 1865 the late Mr. Cromwell Varley tried a Wildes machine on several circuits at the Electric and International Telegraph Company's station in Telegraph-street, London. About 1870 the Lancashire and Yorkshire Railway Company used one at Manchester. In 1872 Mr. Culley experimented with a Gramme magneto machine on several Post Office lines of moderate length. It was found, however, that the trouble arose from the great variations in the strength of the current due to variations in speed, from the rapid corrosion of the contact points in the instruments, and from the intermittent disconnections at the machine. These disconnection were apt to cause serious errors in a message by changing the character under transmission, or at least to produce loss of time by creating repetition.

The improvements made in dynamo machines since 1872 would doubtless overcome these difficulties, but no advantage would be gained by using them for the English system of telegraphy, for it would be difficult to obtain suitable changes of potential, or to adjust the dynamic effects of the very numerous classes of lines radiating from the machine. England, unlike America, is subject to frequent meteorological variations, and the majority of its telegraphic circuits are always liable to a transformation from simplex to complex systems of signalling, or *vice versa*; moreover, the double current open circuit system being in use throughout Great Britain, uniformity of current is absolutely essential, especially where automatic working is in use. Rapid reversals of equal strength cannot be insured from dynamo machine.

In 1879 Mr. Louis Schwendler, the late electrician of the Indian Government, communicated to the *Philosophical Magazine* an interesting account of some experiments he had made with a dynamo-electric machine for signalling purposes, while the dynamo was simultaneously working a powerful electric light. The telegraphic circuits were applied as a leak to the main lamp circuit, and it was apparently found that the small signalling currents tapped off did not produce any perceptible variation of the electric light. He therefore suggested that if the main current from the dynamo could be employed for electric lighting, or other useful work, which would repay the expense of the erection and working of the dynamo electric machine, the signalling currents would cost nothing. This, of course, assumed that the electric light machine was always running.

In telegraphy exceedingly weak currents produce the desired signals. These currents are expressed in milliamperes, (the thousandths of an ampere), and can conveniently be obtained from a battery at pleasure. Furthermore, the number of independent units into which a battery of even a moderate size can be subdivided is a very weighty advantage of which a dynamo-electric machine is wholly void. Now, if dynamo-electric machines were substituted for batteries at convenient English offices, there would still be a very large percentage of batteries required. The Postal Telegraph depot had in use last year 129,789 cells of the bichromate, Daniell and Leclanché type. And if at the seven principal centres where steam engines are working for the pneumatic system all the cells (amounting, approximately, to 38,773) were replaced by dynamos, we should still have 70 per cent. more batteries than those replaced, for which dynamo-electric machines could not be substituted.

I will consider the London central station alone, as it contains about six times more cells than either of the other six offices. In March of the current year there was a total of 687 circuits, radiating from the chief offices through England, Ireland, Scotland, and Wales; and the various classes of circuits require different strength of current ranging from 14 to 80 milliamperes. The full current for all the circuits, viz., 20 amperes, has been approximately determined by adding together the currents necessary for each kind of instrument. The total battery-power for these circuits was about 20,000 cells, which implies an approximate electromotive force of 28,000 volts, or an average of 40·75 volts per circuit. From this data we find that the total electric energy for all the circuits would be $\left(\frac{28{,}000}{687} \times 20\right) = 815$ watts, or 1·09 horse-power, which would equal 0·0016 of a horse-power nearly for each circuit.

The total number of circuits include 290 distinct sets of special apparatus like those aforementioned, and employ 7,956 cells, or an average electromotive force of 11,112 volts. The output of current for these circuits is estimated at 6 amperes, therefore the energy expended equals $\left(\frac{11{,}112}{290} \times 6\right) = 230$ watts, which are equal to 0·3081 horse-power. After deducting this from the total horse-power, 1·09, we have left 0·782 as that which might be developed by

* A paper read at the British Association meeting, Montreal.

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aid of a dynamo-electric machine in place of batteries. But this small amount of energy represents 397 circuits, which must be divided into groups of, say, 40 circuits, to facilitate expeditious removal of faults, as well as to reduce the number of lines subject to stoppage by a fault occurring on either branch within reasonable limits. We should then have to provide eleven dynamo-electric machines, ten for the actual work and one for reserve, for we must endeavour to avoid a long cessation of telegraphic transmission. Suppose the 40 circuits grouped on one dynamo demanded an electromotive force of 40 volts, and a flow of one ampere current from the generator, when all were working simultaneously the maximum horse-power would be 0·053, as compared with the minimum, 0·0013, horse-power required for a single circuit, showing a variation between ·0013 and ·053 of a horse-power. We clearly have an exceedingly small expenditure of electrical energy for a dynamo to develop in compensation for the constant consumption of coal, wear and tear of engine, &c., and incessant attention required. Calculation, however, brings out the annual cost of maintenance of dynamos considerably below the annual cost of maintenance for voltaic cells. We find the mean cost per cell per annum to be 2s., which, for 12,044 cells (the number we assumed to be replaced in the London Post Office by dynamo-electric machines) amounts to £1,204 8s. a year. Now, suppose the dynamos had a commercial efficiency of 80 per cent., the mechanical energy necessary to produce 0·782 of a horse-power, as electrical energy would be 0·977, or say 1 horse-power, and as horse-power requires about 4½lb. of coal for its production, the cost of coal at 20s. a ton for twelve months' running of dynamos averaging 18 hours a day, would be £14 16s., the annual cost may be specified thus :—

Wages of four men at 25s. a week......	£260	0	0
Four per cent. interest on the plant valued at £1,300	52	0	0
Depreciation at 10 per cent..................	130	0	0
Coal at 20s. a ton	14	16	0
Waste and oil	10	0	0
	£466	16	0

which shows a balance of £737 12s. in favour of dynamo-electric machines. Nevertheless there would be a decided disadvantage in using them, not only for the reasons already assigned, but also in the event of fire, when we could not so quickly or so aptly restore communication as with batteries. In the latter, batteries could be easily applied to the respective circuits at the nearest point of safety, whereas engines or dynamos would introduce many difficulties, and cause much loss of time. Finally, it should be remembered that the cost of batteries is so small an item in the general maintenance of the entire system of telegraphy that its consideration may be ignored. It is a question of efficiency and not of economy that will determine their use.

The first experiment with secondary batteries was that of eight so-called half horse-power Faure-Sellon-Volckmar cells, working a universal circuit system consisting of 31 distinct and separate circuits. These worked continuously for seven weeks without the slightest hitch or attention. Then came eight of Mr. Tribe's secondary cells, which were put on a similar universal set of 30 circuits, and worked it successfully for 52 days 2 hours. When exhausted the cells were joined to a dynamo, and a current of three amperes passed through them for 48 consecutive hours, no attendance beyond a casual glance being required. They were again started on the same circuit and lasted 58 days; a third similar charge was given them, and the circuit worked efficiently for another seven weeks. Their behaviour was so good that we had no occasion even to look at them until a day or two before exhaustion. With two of the same kind of cells a local sounder circuit, requiring five of our largest Daniells, was sucessfully worked without any attention for eight weeks. A further and very valuable experiment was also made with twelve Faure-Sellon-Volckmar cells on a universal set consisting of fifteen circuits, which terminated after fifteen weeks, or, excluding Sundays, ninety-two days' work. These were replaced by fifteen double fluid bichromate cells of quart size, and instructions given to carefully note the quantity of material used and time of attention bestowed upon them during the same period of action, viz., fifteen weeks. The particulars of this comparative test were as follow :

The secondary battery worked ninety-two days, averaging twelve hours a day, and the mean current was 0·5 of an ampere per hour, which six ampere-hours = a day, 552 ampere-hours for the whole time.

From what has been stated it will be evident that soon secondary batteries will be made the most economical of the three classes of generators considered. In them there is no waste nor trouble due to diffusion of liquids, as in primary batteries, while they possess all the features necessary for the requirements of the service of large offices. Even while they are being recharged, it would be possible for the circuits to work from the batteries simultaneously.

The only caution we have to exercise is that of preventing the current, in case of a short circuit accidentally occurring from fusing parts of the instruments, or injuring by heat the gutta percha insulation of the leading wires, which run together in large numbers from the battery room to the instrument room. This we can do by constructing the secondary cells with a suitable resistance.

Lastly, it is worthy of notice that a charge of acid does not want renewing. All that is necessary is simply to recharge them electrically.

LITERATURE.

The Electricians' Pocket Book. Being the English edition of Hospitalier's "Formulaire Pratique de l'Electricien." Translated, with Additions, by GORDAN WIGAN, M.A.

This is a work which is much more bulky than is necessary, in that the useful portions of it are too greatly mixed up with what is either unimportant or ill-explained; and its title of *pocket book* is an entirely honorary distinction, for not only has it no pocket itself, but it will not willingly enter any known pocket. In these two particulars it falls decidedly below its German congener by Rohrbeck. Unlike the latter, too, it is printed on disagreeably thick paper, and will not remain open upon a table, an unpardonable sin in books of reference, or indeed in any book.

There is, however, a very great deal of useful matter in the work. Would that it were furnished with an adequate index, in the absence of which much of the usefulness depends upon chance. The mathematical part of the book is far away the weakest, and this is likely to create in the minds of those who find it out an unnecessary doubt about the rest. Thus, at p. 4, in describing the coefficient of induced magnetism, or magnetising function, we have :—"Let H be the intensity of a magnetic field, γ the intensity of magnetisation, the magnetising function k is given by the equation $k = \frac{\gamma}{H}$. It is proportional for very small values of H; beyond such values k is a function of H, which diminishes when H increases, and tends towards a final value, which is called the limit of magnetisation." Possibly this may deceive no one, for nobody who is likely to employ the coefficient of induced magnetism will require to be reminded of the proper connection between k H and γ. The sentence of explanation, if any is required after the formula, should be—"It is constant for small values of H, but afterwards diminishes, and tends to an inverse proportionality to H." There occurs at p. 13 the now commonplace confusion on the subject of energy and power, a confusion which Mr. Preece has been recently exhibiting and reprobating in the same breath in Canada, when charitably endeavouring to show that Professor Adams labours under the same disadvantage. A battery is said to be doing its maximum work when the external resistance is equal to its internal resistance. This is known to be the condition under which most *power* is developed in the external circuit, *i.e.*, when the *rate* of external work is a maximum. If a certain

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number of coulombs, dependent upon the weight and chemistry of the battery, have to flow away before the battery becomes useless, which, whether exactly true or not, is at least the first approximation to the truth, then obviously most work will be done in the external circuit when the resistance is infinite. W_u in the middle of p. 13 should be taken to mean the maximum *power* possible in the *external* circuit, and the equations should be written $W_u = \frac{E\,C_m}{2 \times 9{\cdot}81} = \frac{E^2}{4\,r \times 9{\cdot}81}$.

After this formula the phrase is altered to *rate of work*, which is right, but the casual alteration of important ideas without change of symbol betrays the prevalent confusion of thought, which is also apparent in the expression, p. 16, $W = \frac{E^2}{R}$ *t watts*, instead of *joules*, or *decamegergs*.

The translator has adhered rather too much to assumptions, which would be natural enough in France. Thus, with the calorie at p. 15, there is no sign whatever that the centigrade scale upon which, with the gramme of water, it is based, must be used.

It is very unnecessary perhaps to indicate the fact, but not more so than to indicate the weight (gramme) without the substance (water), and the degree of scale (d) without the kind of scale (centigrade), which is done. It may be said that values of the terrestrial magnetic elements are of little use, as being variable, but at least the values at Greenwich at two epochs would have been of more use to Englishmen than those at Paris, which alone will be found at p. 183. Here, again, the units have led the writer astray. The earth's magnetic field is said to be of so many *dynes*. Now these *dynes* would only be the *force* (C.-G.-S.) which would act on a unit *pole* (C.-G.-S.), if it were there. The field itself has for a formula $[L^{-\frac{1}{2}}\,T^{-1}\,M^{\frac{1}{2}}]$, the same thing as intensity of magnetisation, and to this idea Sir Wm. Siemens gave the name of gauss, though it is doubtful whether he meant the word to apply to the C.-G.-S. unit or to the quadrant unit, which are to one another as $10^{10} : 1$. Force, the C.-G.-S. unit of which is called a *dyne*, is of the dimensions $[L\,T^{-2}\,M]$. The field when acting on a pole $[L^{\frac{3}{2}}\,T^{-1}\,M^{\frac{1}{2}}]$ produces force. The unit of pole is said (p. 40) to have no name. This is an error, as Sir Wm. Siemens called it a weber, though here again it seems doubtful whether weber was to apply to the C.-G.-S. unit of pole or to the quadrant unit, which are as $1 : 10^8$ to one another. Any writer attempting to give formulæ as guides to others should be most careful to define exactly the meaning of his symbols. At p. 22 we have the action of an elemental conductor carrying a current upon a magnetic pole formulated. The form involves the angle α, which is left quite unexplained. It is the angle which the line joining the pole and the element of a linear conductor, makes with the direction of the conductor.

At p. 23 there is the statement that the intensity of the field of a solenoid is at a maximum at the centre. This is misleading, for it is true only when points along the axis of the solenoid are considered. As far as points in the *transverse plane* through the centre are concerned, the intensity is a a minimum at the centre.

The mathematical formulæ in the mechanical portions of the book show signs of having been copied in straight from another source without the limitations to which they are subject being stated. Thus the square of the radius of gyration of a rod bent into the arc of a circle, the axis of rotation passing through the middle of the arc along a radius, is said to be $\frac{r^2}{2}$ when r is the radius of the arc of the circle. This is only true when the angle which the arc forms is some multiple of two right angles. The true square of this radius of gyration is $\frac{r^2}{2}\left(1 - \frac{\sin\alpha}{\alpha}\right)$. Where α is the angle of the arc, $\sin\alpha$ will vanish when $\alpha = n\pi$, n being any integer. Thus the formula, as given in the book, is true for semi-circles and whole circles, but not for other portions of a circle. It is also true for quarter circles, if the axis is a radius passing through the end of the arc.

Having mentioned most of the errors and oversights which have presented themselves more obviously, it will be only candid to say that these form a very minute portion of the whole work, the practical matter of which seems very well selected, and only to want a thorough index. At the end of the book are a good many pages of diagram paper, ruled to squares whose areas are ·25 C.-G.-S. units. This is an excellent point in itself, and would be still more valuable if the work were a real pocket book. To point out slips will, it is hoped, only render a useful book more useful, and it is in this mood that the book has been dealt with now. It is satisfactory to learn that Mr. Wigan contemplates issuing it periodically, and if it reappears as a real pocket book we hope that the period will be 31·6 mega-seconds.

PROFESSOR ROWLAND'S PRESIDENTIAL ADDRESS AT THE PHILADELPHIA CONGRESS.

(*Concluded from page 483.*)

Many years ago I myself experimented on the subject and obtained a result about 4 per cent. too high. Recently Lord Rayleigh has taken up the matter and made a series of experiments of unparalleled accuracy in this line. The International Commission, determined on by the Electrical Congress in Paris in 1881, met in April of this year at Paris, and has now given us a legal ohm defined as being the resistance of a column of mercury 106cm. long and 1mm. in section at 0° C. The length best satisfying the experiments is about 106·25, but it was considered best to use the round number. The experiments which I have been making under an appropriation from the Government are now barely completed, but they will probably agree very well with the latter figure. Hence, we can say that we now know this unit of resistance to one part in one thousand, at least. And so we are in a position to measure the energy of a current to the same degree of accuracy, as far as this quantity is concerned.

But to measure a current by the tangent galvanometer one requires to know the intensity of the earth's magnetism, a quantity difficult to determine and constantly varying with time and place. The electro-dynamometer, when made with care, is excellent, but a good one is immensely expensive. Our methods, then, of current measurement are bad, unless carried out in a completely equipped physical laboratory. With a practical standard of electromotive force, such as a Clark's standard cell or a thermo-electric battery, this difficulty partially vanishes. Better, perhaps, we might make simple electro-dynamometers with constants determined by comparisons with a more costly instrument.

But where shall these standards be kept? Evidently the Government, which decides on our standards of weights and measures, should take in charge the electrical standards, and possibly also the thermometric standards. The formation of such a bureau of physical standards will be brought to the attention of this conference.

Having given certain standards, then the measurement of currents and current energy becomes easy. The amount of heat generated in a wire of known resistance by a known current is also easily found from the absolute system of electrical measurement.

Besides the two so-called absolute systems of measurement of electricity and electric currents, we have also one based on the chemical action of the current whose laws were discovered by Faraday. Knowing the electro-chemical equivalent of some substance we are able to measure the time integral of the current or the total quantity of the current which has passed.

The absolute measurement of magnetism is equally simple with that of electricity, and it is a common observation to find the earth's magnetic force. But Faraday has put in our hands a very simple method of measuring a magnetic field, and to-day all are familiar with his beautiful laws with respect to magnetic lines of force. We know the laws of electro-magnetism, and just how many lines of force (better induction) can pass through a piece of iron of given cross section, and what is their relative resistance when passing through air or iron. In fact, we have all that is necessary for a complete theory of the dynamo-electric machine, and consequently we find that the latter agrees perfectly with theory, and no fact has been observed with reference to it which could not have been foreseen from theory by a person of proper intelligence.

This part of electrical science, the measurement of electrical and magnetic quantities, is thus in a very forward state, based as it is on the mathematical theory of the subject. But, in reality, this forms but a very small portion of our science. Shall we be contented with a simple measurement of what we know nothing? I think nobody would care to stop at this point, although he might be forced to do so. The mind of man is of a nobler cast, and seeks knowledge for itself alone. We are not so base as to be honest because "Honesty is the best policy," neither are we so ignoble as to seek knowledge because "Knowledge is power," two sayings which are certainly true, but low and sordid in their tone.

We have, then, the beautiful fabric of mathematical electricity given to the world by Poison, Green, Helmholtz, Thomson, Maxwell, and others whose names are immortal. No hypothesis as to the nature of electricity rests at its base. Starting from the most simple laws of electricity and

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magnetism, it rises from a stable foundation and rears its form high in air, never to be overturned, whatever the fate of the so-called electric fluid or the ultimate theory of magnetism. On the simple fact that there is no electric force inside a closed conductor, it is proved that the electric attraction and repulsion varies inversely as the square of the distance. This fact is sufficient to give us the whole theory of electrostatic distribution on conductors.

From the simple fact that we can break a magnet up into parts which are similar to each other, and that these parts attract and repel each other in a certain manner, we derive many important facts with regard to magnetism.

From the magnetic action of the current we find, by an application of the great law of conservation of energy, all the laws of induced currents, either from magnets or other currents. By an almost superhuman effort of the intellect we detach our electric currents from matter, and suppose them to take place in the ether of space, and we have the grand electro-magnetic theory of light given to us by Maxwell.

But the subject is too vast to be treated in a moment. Suffice it to say that no person at the present day has the right to express an opinion on any theoretical question connected with electricity without a knowledge of its mathematics.

This study has led us to alter our ideas on many questions. What is the mechanism of electric or magnetic attraction? Faraday has given us his idea of lines of force, and has made them play an important part in the theory of magnetic induction. When treated mathematically, Maxwell has shown that all electric and magnetic attractions can be explained by a tension along the lines of force and pressure at right angles to them, an idea due to Faraday.

The mathematical theory of these lines shows that all electro-static forces between either conductors or non-conductors can be explained in this manner. As the laws of magnetic attraction are the same in every way as electro-static attraction, if we should do away with electric conduction, it follows that magnetic attraction is to be explained in exactly the same manner. In obtaining this result Maxwell calculated the forces acting on the medium at every point, and compares these with imaginary stresses in a medium at the given point. Hence, the energy stored up can be represented either as due to the mutual attraction of the electricity at a distance or to the stresses in the medium at every point, and thus, as Thomson has shown, by a volume integral of the square of the force at every point. Hence, we are at liberty to deny the existence of all action at a distance and attribute it to the intervening medium, which, to be logical, we must assume to be continuous and not molecular in constitution.

Thomson has pointed out that magnetism must be of the nature of rotation, such as possibly vortex motion in a fluid, and Maxwell has done something towards making a mechanical model of such a medium. Thomson's wonderful address at Montreal has also given us much to think of in the same direction.

But here we have reached the limit of our science, and even that servant of our reason, imagination, fails us. We are yet unable to picture to ourselves what takes place in a medium subject to electro-static action. We are face to face with the great problem of nature and the questions, what is matter? what is electricity? evoke no answer from the wisest among us. Our mathematics have guided us safely up to a certain point, and will guide us still further; science will advance and we shall know more. But, for the present, this is the limit which we have as yet attained in this direction. However, the idea of a medium is still serviceable in other portions of our science.

We have seen that the medium explains the electrical and magnetic attraction of bodies at rest. The question then comes up as to what happens in the medium when these bodies move. Are the imaginary stresses in the medium transmitted from place to place instantaneously, or do they require time? Mathematics in the hands of the immortal Maxwell have answered this question, and we now know that any magnetic or electric disturbance is propagated through space with a velocity equal to the ratio of the electro-magnetic to the electro-static unit of electricity. This great physical constant has now been found by experiment to be equal, to the velocity of light, and thus has arisen that great modern theory, Maxwell's electro-magnetic theory of light. Indeed, at the present day, so perfectly does this theory agree with experiment that we can almost regard it as a certainty. The velocity of light and the ratio of the units agree far within the limits of experimental error. The fact that bodies having a true (not electrolytic) electric conduction are always more or less opaque, the refraction and dispersion of light, double refraction and diffraction, all are explained on this theory with an ease and simplicity wanting in all other theories; and lastly, an electro-magnetic phenomenon has been discovered, which, when applied to this theory of light, explains the rotation of the plane of polarisation produced by a magnet. There is no fact in nature seriously in disagreement with this theory, and it serves to connect two of our most important branches of physics, light, and electricity.

But some physicists say that it is not a true theory because it is not mechanical, the object of these physicists being to reduce every phenomenon of nature to matter and motion. Whether this is necessary or not I leave to the philosophers. But it is to be noted that the old mechanical theory that light is a vibration in a medium having the properties of an elastic solid is not entirely at variance with the new theory. The medium we call ether. The electro-magnetic theory says that the waves of light are waves of electric displacement, while the old theory says they are waves of ether. Make electricity and the ether equal to each other and the two theories become one. We have arrived at that hazy and unsatisfactory theory of Edlund that ether and electricity are one, except that by this theory electricity is presented to us as an elastic solid!

But the ground trembles beneath us, and we shall soon be plunged in the mire of vague speculation if we do not draw back.

Among the other questions which depend for their solution on the presence of a medium may be mentioned the mutual action of two electrified bodies moving in space. It has been found that electricity carried through space on a charged body has exactly the same magnetic effect on a stationary magnetic needle as if it had been conducted.

But when electrified bodies move uniformly forward in space we can conceive of no mutual effect from such motion unless it is relative to a medium. For we cannot even conceive of absolute motion.

Assuming the medium to exist, we then know that a positively and negatively charged body flying through space with the velocity of light would have their electric attraction just balanced by their magnetic repulsion, and so would exert no force on each other.

But it is a most wonderful fact that we have never been able to discover anything on the earth by which our motion through a medium can be directly proved. Carried as we suppose by the earth with immense velocity through regions of space filled with ether, we have never yet been able to prove any direct influence from this etherial wind.

The assumption of a medium allows us to solve in some cases that problem so long under discussion by electricians—namely, the true velocity of an electric current. We now know that the term velocity hardly applies to this case, and that the current arrives at different points so gradually that we know not when to say it has arrived. But there is certainly a minimum time when even an infinitesimal current can reach a distant point. Suppose two wires stretched in space with their ends near together at one end, and a Leyden jar be discharged from one to the other at the near end. The *minimum* possible time of obtaining a spark at the distant end will evidently be the time required by light to pass from the Leyden jar to the distant point, not around the wire, but in a straight line. In this case the greatest maximum velocity is thus twice that of light reckoned around the wire, and may be any amount greater when we bend the wire. For all ordinary distances this velocity may be considered infinite, and the retardation to depend only on the electro-static capacity and magnetic self-induction of the wire. Treated in this way, we have Thomson's mathematical theory of the propagation of an electric wave along a telegraph wire or cable, a theory of great practical use in telegraphy and telephony. But until the action in the external medium is also taken into account, it can only be considered an approximation. For we can never move a magnet, discharge a Leyden jar, or complete the circuit of a battery, without causing a wave of electro-magnetic disturbance in the ether, and every signal which is sent along a telegraph line is accompanied by a wave in the ether, which travels outward into space with the velocity of light. Truly, the idea of a medium is to-day the keystone of electrical theory, but we can hardly suppose that it has even yet attained a fraction of the importance to which it is destined to rise.

Let me now call your attention to one of the most wonderful facts connected with electrical science. When we are dealing with the electro-static action of electricity, we find that it is the so-called electric fluid which attracts the opposite. Not only do we observe the attraction of bodies oppositely charged, but the electricity itself on the two bodies is displaced by its mutual action. But when we come to investigate the mutual attraction or repulsion of electric currents on each other, we find an entirely different law. In this case the conductors carrying the currents attract or repel each other, but the currents within those conductors have no influence of attraction or repulsion to displace themselves within the body of the conductor. In other words, the current is not displaced by the action of a neighbouring magnet, but flows on calmly as if it were not present.

This to me is one of the most wonderful facts in electrical science, and lies at the foundation of our science. It cannot be ignored in any further progress we may make in electrical theory, but points out a radical difference between electro-static and electro-magnetic action.

I have said there is no action of a magnet in displacing an electric current, and have thus stated the broad general fact, and which is perfectly true in some metals. But in others there is a small action which changes in direction with the material. The elements of the electric current within the material are rotated around the lines of magnetic force; sometimes in one direction and sometimes in the other, according to the material. But the action is, in all cases, very weak. When applied to the electro-magnetic theory of light, this action leads to the magnetic rotation of the plane of polarisation of light. As to the explanation of both these actions, Thomson has remarked in the case of light, from dynamical considerations, the rotation can only come from a true rotation of something in the magnetic field, and leads us to think of all magnetic action as of the nature of vortex motion in a fluid. But here our theory ends for the present. We have obtained a clue, but it is not yet worked up.

I have now taken a rapid glance at some of the modern advances of electrical science, and we have not yet had to give up the old idea that electricity is liquid. To the profound thinker this idea is very vague, and there are some facts at variance with it, but it is still useful. We often hear persons say that this old idea is gone, and that electricity is "force," whatever they may mean by that. But let us see. The work or energy of an electric current between any two points is the quantity of electricity passed multiplied by the potential; this work goes to heating the wire. Let a current of water be passing in a pipe and the quantity of water multiplied by the difference of pressure between two points gives us the work which has been done in the intervening space, and which has produced heat. The analogy is complete. No electricity has been destroyed in the one case, or water in the other, but the work has come from the fall of potential in the one case, and the fall of pressure in the other; the resultant is the same in both—heat. Again, we can obtain work from the mutual attraction and repulsion of electrified bodies, and the work in this case always comes from the change of potential between the bodies while the electric charges remain undisturbed in quantity. Electricity, then, is not energy, but is more of the nature of matter.

So far for electricity in the state of rest or steady flow. But when it changes from rest to motion, all known liquids have a property known as

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inertia; furthermore, they have weight. But the electric fluid has neither inertia nor weight as far as we have yet experimented, and in this respect differs from all known matter. Furthermore, we have never yet been able to separate electricity from ordinary matter. When we pass electricity through a vacuum, the resistance becomes less and less, and one may have hopes of finally having an electric current through a vacuum. But, as the exhaustion proceeds, we observe that the resistance begins to increase until it reaches such a point that no discharge can take place. Electricity cannot exist, then, without matter, a fact fatal to the idea of a fluid, however useful that may be. We have but one conclusion from this, and that is that *electricity is a property of matter*. Do with it what we may, it can never be separated from matter, and when we have an electrical separation the lines of force must always begin and end in matter.

The theory of matter, then, includes electricity and magnetism, and hence light; it includes gravitation, heat, and chemical action; it forms the great problem of the universe. When we know what matter is, then the theories of light and heat will also be perfect, then and only then shall we know what is electricity and what is magnetism.

It is the problem of the universe which *looms* up before us and before which we stand in awe. The intellect of the greatest among us appears but feeble, and we all, like Newton, appear but as children on the sea-shore. But how few of us find the shells which Newton did, and how few of us try. The problem is vast, and the means for its solution must be of corresponding magnitude. Our progress so far has been but small. When we push our inquiry in any direction we soon reach a limit; the region of the unknown is infinitely greater than the known, and there is no fear of there not being work for the whold world for centuries to come. As to the practical applications which await us, the telegraph, the telephone, and electric lighting are but child's play to what the world will see in the future.

But what is necessary to attain these results? We have seen how the feeble spirit, which was waked up by friction in the amber and went forth to draw in light bodies, has grown until it now dazzles the world by its brilliancy, and carries our thoughts from one extremity of the world to the other. It is the genius of Aladdin's lamp which, when thoroughly roused, goes forth into the world to do us service, and returns bearing us wealth and honour and riches. But it can never be the servant of an ignorant or lazy world. Like the genius of Aladdin's lamp it appeared to the world when the amber was rubbed, but the world knew not the language in which to give it orders, and was too lazy to learn it. The spirit of the amber appeared before them to receive its orders, but was only gazed at in silly wonder, and retired in disgust. They had but to order it and it would have gone to the uttermost part of the earth with almost the velocity of light to do their bidding. But in their ignorance they knew not its language. For two thousand yea s they did not study it, and when they then began to do so, it took them two hundred and fifty years to learn the language sufficiently to make a messenger of it. And even now we are but children studying its A B C. It is knowledge, more knowledge, that we want.

I have briefly recounted the advances which we have now made in one science, and, however beautiful it may appear, we have soon reached the limits of the known, and have stood in wonder before the vast unknown. For very much of our science we see no practical applications, but we value it no less on that account. We study it because we have been gifted with minds whose exercise delights us, and because it seems to us one of the highest and noblest of employments. And we know by the history of the past that the progress of the world depends on our pursuit, and that practical applications, such as the world has never even conceived of, await us. It is necessary that some should go before to clear the way for the world's advance.

This is the work of the pure scientist; to him the problem of the universe is worth devoting his life, and he looks upon wealth as only adding to his means of research. He hopes not to solve the problem himself, but is contented if he may add some small portion to human knowledge; if he may but do his part in the march of human progress. He looks not for practical applications, but he knows full well that his most abstruse discoveries will be made useful to mankind at large, and so troubles himself no further about it.

The science which he creates is studied by others. Their minds are educated by it, and their hearts entranced by its beauties. And some are led to devote their lives to its further advancement. But the whole world benefits by it intellectually. The wayward spirit of the amber has vanished for ever, and prosaic, law-abiding electricity has taken its place even in the estimation of the most ignorant. The world has advanced, and in great part from the study of science.

Then comes the practical man who sees that other benefits can be reaped besides those of pure intellectual enjoyment. While the investigator toils to understand the problem of the universe, the practical man seeks to make a servant of our knowledge. He seeks to increase the power of our bodies and so make the bonds by which the mind is united to it less irksome. It is he that increases the wealth of the world and thus allows those so disposed to cultivate their tastes and to elevate themselves above the savages. The progress of the world depends upon his inventions.

Let not, then, the devotee of pure science despise practical science, nor the inventor look upon the scientific discoverer as a mere visionary person. They are both necessary to the world's progress, and they are necessary to each other.

To-day, our country, by its liberal patent laws, encourages applied science. We point to our inventions with pride, and our machinery in many of the arts is not surpassed. But in the cultivation of the pure sciences we are but children in the eyes of the world. Our country has now attained wealth, and this wealth should partly go in this direction. We have attained an honourable position in applied science, and now let us give back to the world what we have received in the shape of pure science. Thus shall we no longer be dependent, but shall earn our own science as well as inventions.

Let physical laboratories arise; let men of genius be placed at their head, and, best of all, let them be encouraged to pursue their work by the sympathy of those around them. Let the professors be given a liberal salary so that men of talent may be contented. Let technical schools also be founded, and let them train men to carry forward the great work of applied science.

Let them not be machines to grind out graduates by the thousand, irrespective of quality. But let each one be trained in theoretical science, leaving most of his practical science to be learned afterwards, avoiding, however, overtraining. Life is too short for one man to know everything, but it is not too short to know more than is taught in most of our technical schools. It is not telegraph operators but electrical engineers that the future demands.

Such a day has almost come to our country, and we welcome its approach.

Then and not till then should our country be proud, and point with satisfaction to her discoveries in science, pure *and* applied, while she has knowledge enough to stand in humiliation before that great undiscovered ocean of truth, on whose shores Newton thought he had but played.

SELECTED CORRESPONDENCE.

THE RECENT FATAL ACCIDENT AT THE HEALTH EXHIBITION.

The following correspondence has appeared in the London and provincial press in reference to this subject:—

TO THE EDITOR OF THE TIMES.

Sir: The recent accident to an attendant on a dynamo machine at the Health Exhibition, which caused his death, may very seriously prejudice the minds of those about to use the electric light in their houses. Will you allow me, through the medium of *The Times*, to point out that currents of extremely high electromotive force, such as that which caused the accident, have never been, and can never be, used for electric lighting in the form of the incandescent lamp, which is the only form suitable for domestic use?

My intimate connection with electric lighting has rendered it necessary for me to obtain exact data as to the extreme safe electromotive power or electrical pressure which can be safely used in situations accessible to the touch of human beings or animals. I have never been able to trace any accident to life or even injury to health from contact with electric wires, provided that the electromotive force has not exceeded 600 volts. The object of using such high pressures is to economise the weight and cost of conductors when the lamps are scattered over a wide area; but at the Health Exhibition there was no such necessity for economy, and it is much to be regretted that those responsible for the scientific management of the Exhibition should have allowed such dangerous pressures to be used in such a crowded and unprotected situation.

The electric light has had a hard battle to fight, and this bugbear of the supposed danger to life has not been one of the least of its enemies. So long as currents of low electrical pressure (such as are used with incandescent lamps) pass through the wires, they may be safely touched with one or both hands by a young child or delicate person with absolute impunity, and with no disagreeable sensation beyond a slight pricking, if the hands are damp. These facts are, of course, well known to the scientific world; but to the untrained public there is only "one kind of electricity," and they cannot readily understand why it should be dangerous to life in one form and not in another.

Your obedient servant,
R. E. CROMPTON.

Mansion House-buildings, E.C., Oct. 4.

TO THE EDITOR OF THE DAILY CHRONICLE.

Sir: The recent sad fatal accident in connection with a dynamo machine at the International Health Exhibition has naturally caused a good deal of comment, and may probably lead many of the public to believe that danger is inseparable from the use of dynamos. As this would be extremely prejudicial to the business of this company, I trust that you will permit me to say that the Edison dynamos supplied by this company do not generate a current of sufficient electrical tension to be in any way dangerous to life or limb. It is difficult to understand why any one should put a dynamo which may occasion a serious or fatal accident into a factory, or house, or ship, when machines of greater electrical efficiency, and containing no element of danger to the person, can be purchased as cheaply as these undoubtedly dangerous machines.—I am, Sir, your obedient servant,

S. FLOOD PAGE, Secretary.

Edison and Swan United Electric Light Company (Limited),
57, Holborn-viaduct, E.C., Oct. 4.

TO THE EDITOR OF THE MANCHESTER COURIER.

Sir: The recent death of an electrician at the Health Exhibition, while oiling a dynamo machine, has doubtless caused alarm to some who think of adopting the electric light in their houses. The circumstances of the case have not been clearly given in any of the public papers. I think it right, therefore, that it should be stated that, in incandescent lighting, there is not the slightest danger, and little inconvenience, experienced from handling the naked terminals of a machine driving a circuit of

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Edison lamps; and as the resistance of the Edison lamp is higher than any other form of incandescent lamp, it follows that the inconvenience is still less when lamps of the Swan type are used. What I have said may be put to the test any evening by any one who will visit this company's central station in Mount-street. Here the current for lighting the Theatre Royal is generated; and any one who cares to do so may handle the terminals of the powerful dynamo machines employed without suffering more than a slightly uncomfortable feeling such as is usually experienced when receiving a "shock" from an ordinary electrical machine. The reason of this is that incandescent lamps are generally run in what is called "multiple arc," by which means the tension employed remains the same, whether one lamp be used or a thousand. Arc lamps, on the contrary, are usually lighted "in series;" in other words, the current is forced through each in succession, and must necessarily have an electromotive intensity capable of overcoming the combined resistances of the total number of lamps. As arc lamps usually need somewhat more than 40 volts of electromotive force for each, and as there were in this case 25 arc lamps "in series," it follows that more than 1,000 volts were passing through the circuit. This, you will observe, is 10 times the force employed in incandescent lighting, and it is this difference between the two methods of producing the electric light which it is desirable to make clear to your readers. When large numbers of arc lamps are lighted "in series" there is always danger, and the greater the number, the more the danger. But when incandescent lighting has been properly prepared for, by a careful installation carried out by competent persons, and with conducting wires of sufficient sectional area, there is no mode of producing artificial light at once so pleasant and so free from danger, either to life or from fire. This last mentioned advantage has not yet been sufficiently recognised by the insurance offices; but with the increaseing premiums now being demanded from Manchester warehouses, for covering fire risks, it cannot be long before the incandescent light will be included amongst those "safety appliances," for the adoption of which a liberal discount from fire premiums is allowed. My object, however, is not at present to discuss this question. My purpose will have been served if I shall have removed any needless alarm on the subject of incandescent lighting.—Yours, &c.,

GEO. FREEMANTLE, Secretary.

The Manchester and District Edison Electric Light Company (Limited), 19, Victoria-buildings, Manchester.

COMPANIES' MEETINGS & REPORTS.

Great Western Electric Light and Power Company (Limited).

The second ordinary general meeting of the shareholders of this Company was held at the City Terminus Hotel, Cannon-street, on the 6th inst., under the presidency of Mr. J. B. Braithwaite, jun.

The notice convening the meeting having been read, and the minutes of the last meeting read and confirmed,

The CHAIRMAN moved the adoption of the report. He observed that the efforts of the Board had of course been directed to two main things—first, to reduce the expenses of the Company, and get them on a satisfactory basis; and in the second place, to develop, if possible, a profitable business in electrict lighting in their district. They had reduced the expenses to a considerable extent, and with regard to the receipts, they were also glad to be able to state that, as far as their lighting stations were concerned, the receipts had been almost trebled during the year. The other business they had undertaken during the year had been of a very limited amount, owing to the fact that, though a large amount of business had been offering, only a small portion could be regarded by them as at acceptable rates. There had been a very large number of companies who had been willing to take work at no profit, and sometimes even at a loss, for the purpose of advertisement. They themselves had had a large number of inquiries from people who had business to offer on such terms as these, but he was glad to say that those people who thought that the Company would undertake work for nothing were disappearing, and that they were receiving inquiries from more substantial quarters. Passing to the report, he stated that with regard to the reduction of the capital he ought perhaps to apologise for the fact that the meeting of the Company this year was held somewhat later than before. The reason for this was that the Directors had thought it would be more satisfactory to the shareholders when they met to know that their liability in respect to their shares was wiped out. The assent of the Court to the reduction of the capital was only given on the 6th of August, and there was a further month during which the liability existed. Therefore their liability did not end really until the 6th of September, but it was now wiped out, and that part of the pledge which the Directors gave when they took office had been fulfilled. As to the claim made against them by the liquidator of the Devon and Cornwall Electric Light Company, that gentleman had very properly, and in accordance with his duties, no doubt, made a claim on this Company amounting to a very large sum—for the whole of the purchase money, both in cash and shares, for the money spent in the wrecking of the Company (or the working of it, as it had been called), and for the whole of the money sunk in plant. This matter had given the Board very great anxiety, but they were glad to be able to announce that it had been settled. They had surrendered the fully paid shares allotted to them in the Devon and Cornwall Company, and the 500 shares purchased by the late Board, on which they had paid £1,250. Besides that when the liquidation of the Devon and Cornwall Company was completed they would allot to the shareholders in that Company 3,000 fully paid shares of this Company, at £2 10s. each. The result of these proceedings was that the claim which had been made by the liquidator of the Devon and Cornwall Company had been withdrawn, and the Directors had been enabled to proceed with the reduction of the capital of the Company. As he had said, that liability was now wiped out, and really the practical result was this—that, for the first time, they had control of their property, because, while they had the claim referred to hanging over them, it would have been impossible, had they desired to do so, to wind up the Company. Their property was not their own until they had got rid of this claim. They were now, for the first time, free from all litigation, and free to go forward with the business of the Company. With respect to the lighting stations, they were a bequest of the late Board, and the Directors had done, and were doing, their best to develop them, in order that they might become profitable. They had a considerable amount of money locked up in plant at these stations, and it was necessary for them, if possible, to utilise them. Their efforts during last year had resulted in a large reduction in the working expenses, and an increase of some 200 per cent. in the receipts. This increase was still going forward. Since the report was issued they had received a considerable number of new orders for lights from these stations, and they quite anticipated in the coming year to be able to bring about an equilibrium between receipts and expenditure at them. They had purchased a portable plant, which they had found very useful for developing the lighting throughout their district. There were many places where their light had not been shown, and in those places people did not know what it was. They had, therefore, spent a small sum on this portable plant, which they could send at two or three days' notice to any part of their district for lighting up flower shows, bazaars, &c. The plant paid very well in itself—for they received very good rates for these installations—and, in addition, it tended to make the Company and the light known throughout their district. They had taken steps to canvass two or three likely towns in their district to see what prospect there was from putting down their apparatus, but so far they had not received such indications of support as would warrant them in proceeding further. With respect to the Anglo-American Brush Corporation, they had opened negotiations with them, the result of which had been that in exchange for the right which they had given to the Corporation to light railway trains in their district, and to put up the plant necessary for the purpose, they had surrendered to this Company £5,750 in fully paid shares of the Company. The directors regarded this as an advantageous arrangement, as it reduced the capital of the Company to the extent mentioned. As to the future, he did not think he could add much to what was stated in the report. They trusted, by prudence and economy, to be able to carry on the Company at a small outlay. That was the worst view. They had, however, now got the Company established on a satisfactory and commercial basis, and it was merely a question whether there was enough business to do to give them a sufficient margin of profit. They saw indications on all sides that the electric light was coming to the front. Every new building was now either lighted with the electric light, or arrangements were made for the purpose. This showed that the electric light was regarded as the light of the future. With regard to the result of the year's trading, unfortunately they had made a cash loss on trading account of £538, and they had also made a paper loss of £529, the latter representing the amount written off for depreciation. The total loss for the year had thus been £1,067. In drawing the accounts they had written off that loss against the amount received from the Brush Company in shares, and they had written back the balance which remained to the credit of profit and loss, to meet the shares which they had arranged to give to the liquidator of the Devon and Cornwall Company. He concluded by moving the resolution.

Mr. C. H. STEWART, in seconding the motion, said he could confirm all that the Chairman had stated as to the difficulties which the Directors had had in adjusting matters with the Devon and Cornwall Company and the solicitors connected with the bringing out of that Company. He need not say that all these complications had arisen from the accounts of the late Board, but he was very glad to say that they were now all closed, and that they were now in a position to go on with the business of the Company. It was simply a question whether the public would take to the electric light, but they would do so if they followed in the footsteps of their American cousins. The electric light was now in use in almost every town in the United States, and many of the mines there were similarly lighted. For his own part, he believed that if it had not been for the unjust legislation of the Government, which seemed to him to have been entirely in favour of the gas companies, much more progress would have been made with the electric light in this country. He, however, looked to the justice of Parliament to rectify the mistake which had been made, and to introduce a Bill in the coming session with that view, which might give a fair chance to electric light companies. He would advise the shareholders to continue to have confidence in the Directors. They would do their utmost to carry on the Company with the least possible expense, and they would only take orders where they saw a prospect of obtaining some small profit. He hoped at the end of next year that the Directors would be able to come before the shareholders with a more favourable statement than that which they submitted on the present occasion.

A short discussion followed, in which Messrs. HILYARD, COLE, and BROOKER took part, the latter gentleman suggesting that while the Company had a little money left the Directors should divide it among the shareholders. He was convinced that the thing would not pay, and that therefore it would be wise for them to get back what they could.

The CHAIRMAN said that Mr. Hilyard had asked for an explanation of the difference in the amount on deposit as compared with last year. Well, there was a difference of £1,500 in the amount owing to the Company, as

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Mr. Hilyard had himself pointed out. Then there had been a loss on the lighting stations of about £800, and they had invested in plant—machinery and materials—roughly, to the extent of about £1,000.

Mr. HILYARD asked the Chairman to show at once how the difference of £4,000 was to be accounted for.

The CHAIRMAN: We show a loss of £81,000 on the year. There has been an increase of £1,700 in the amount of plant in stock, and there is a difference of £1,500 in the amount owing to us; that makes £4,200. In further reply, he stated that the number of shares allotted had been 22,000, and not 20,000 as stated in the balance sheet, owing to a clerical error. Altogether, with the vendor's shares, the number allotted was 24,744. There were 25,000 unissued, 3,000 of which they proposed to issue in due course to the liquidator of the Devon and Cornwall Electric Light Company. He had been rather surprised to hear Mr. Brooker say in one breath that the Directors were honest men, and in the next breath to state that they were aware that the Company could not possibly pay. If that were the view of the Board they would recommend the shareholders to wind up immediately; but they thought that there was a possibility of the Company paying. As to the expenses, they amounted last year to £1,676, and they expected in the course of the current year to reduce that amount to well within £1,000—they anticipated to between £800 and £900. Their receipts, too, at their lighting stations and from their general trading went on increasing. He might point to the last number of *The Electrician* to show that electric lighting was going on at an increasing ratio, and particularly with the Brush system. People were getting rid of the idea that they could obtain the electric light for nothing, or that they could have it for less than gas. They had never had one customer leave them on account of the light, but they had cut off one or two through their not having paid. No one had given up the electric light because he did not like it. On the contrary, many of them had increased the number of lights, and also the price paid to the old Board. On behalf of himself and his co-Directors he would say that the moment they came to the conclusion that there was no prospect of the Company paying, that moment they would recommend and urge the shareholders to wind up. The full amount of the Directors' fees was £1,000, but they were content with £500 for the year. The motion was then carried unanimously.

Mr. OFFOR next moved the re-election of Mr. Braithwaite as a Director of the Company. He stated that he could endorse the remarks of the Chairman as to the future, and he thought the immediate future. Those who studied the journals connected with electric lighting would thoroughly agree with the Chairman when he said that they were now in a very much better position than they were twelve months ago. They had had difficulties to contend with, no doubt, as to the Electric Lighting Act, and they had also other difficulties. They had had their partners in the electric light business proclaim to the world that the business was a failure. He thought that that was a great mistake, and his opinion was that those who were partners in the business should do their utmost to inspire confidence in the public.

Mr. LADD, in seconding the motion, expressed his belief that the Directors were doing all they could for the benefit of the Company. Electric lighting was, he said, steadily increasing—he knew that from the Anglo-American Brush Corporation. They were now doing work in other districts, and he did not see why the Company should not increase in the same way in the district they served. The motion was then carried unanimously.

The CHAIRMAN, in reply, expressed his thanks for the confidence shown in him by his re-election, and stated that the Directors during the current year would do their utmost to make the Company a paying concern.

The auditors, Messrs. Turquand, Youngs, and Co., were next re-elected, and a vote of thanks to the Chairman and Directors brought the meeting to a close.

Eastern Extension, Australasia, and China Telegraph Company.

Report of the Directors for the six months ended 30th June, to be presented at the twenty-second ordinary general meeting of the Company, to be held at the Cannon-street Hotel on Wednesday, the 15th inst., at two o'clock:—

The gross receipts, inclusive of Government subsidies, have amounted during the half year to £237,672 11s. 5d., against £213,729 4s. 5d. for the corresponding period of 1883, showing an increase of £23,943 7s. The working and other expenses (including £22,784 5s. 9d. for cost of repairs and laying of new cables and expenses of ships) absorb £66,658 18s. 9d. against £62,778 11s. 7d. for the corresponding half year of 1883, leaving a balance of £171,013 12s. 8d. From this is deducted £2,002 17s. for income tax, and £41,595 for interest on debentures and contributions to sinking funds, leaving £127,415 15s. 8d. as the net profit for the half year, against £107,356 2s. 1d. for the corresponding period of 1883. Against this the Directors have charged £22,767 17s. 7d. for the partial renewal of the Java-Australian (original) cable, which is referred to below. One quarterly interim dividend of 1¼ per cent., amounting to £31,250, has been paid during the half year, and it is now proposed to distribute another of like amount, together with a bonus of 2s. per share, payable on the 15th inst., making a total payment of 3½ per cent. for the half year, leaving £17,147 18s. 1d. to be carried forward. In accordance with the provisions of the Trust Deed dated 10th May, 1879, 909 Five per Cent. Australian Government Subsidy Debentures were drawn on the 23rd April last for payment at par on the 1st July. Up to date 654 debentures have been presented, and paid off by the trustees. During the half year under review the policy of strengthening the Company's system by judicious extensions, and the renewal of those portions of the cables exposed to damage from the teredo has been continued. The cable between Tonquin and Hong Kong, to which reference was made in the last report, has been successfully laid by the Company's steamship "Sherard Osborn," and opened for traffic. The cost of the same, and of the cable between Cape St. James, Thuan-an, and Tonquin is shown in the capital account. The cable between Hong Kong and Macao has also been completed and opened for traffic. The cost of this will appear in the current half-year's accounts. It will be satisfactory to the shareholders to learn that during a recent short interruption of the direct Hong Kong-Cape St. James cable the whole of the China traffic was transmitted *viâ* Tonquin without any appreciable delay, thus showing that the new cables give the Company a valuable alternative route between Cochin-China and China. The operation of picking up the old cable on the Sahul Bank, which has been renewed by brass-ribboned cable, as stated in the last report, was attended with considerable success, 394 knots being recovered out of a total length of 404 knots. This cable has been taken into the spare cable account at a moderate valuation, and when it has been overhauled and re-served on board the Company's hulk at Singapore will be available for renewals or extensions in other directions as required. By these means the cost of the renewal is reduced to £22,767 17s. 7d., which has been met, as shown in the accounts, without any addition to capital expenditure. The threatened opposition line *viâ* Tavoy, which was likewise referred to in the last report, has been closed for several months past owing to excessive mortality amongst the staff employed, and to difficulties of maintenance during the rainy season. It is, however, expected to be re-opened during next month. Several cable interruptions have occurred at various points of the system, which have given the repairing ships full employment during the half year. The traffic, however, has been transmitted by the duplicate lines. All the Company's cables, with the exception of the Saigon-Hong Kong and Hong Kong-Tonquin sections, which are expected to be repaired in a few days, are in good working order. The Government land line between Port Darwin and Adelaide has been well maintained by the South Australian Government during the half year.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. OCT. 8.		BUSINESS DONE WEEK ENDING OCT. 8. Highest.	BUSINESS DONE WEEK ENDING OCT. 8. Lowest.
Anglo-American	34,	35	34¾	31¾
Do. Preferred	57½,	58½	59¼	55¾
Do. Deferred	7¼,	7¾	8	7⅝
Brazilian Submarine	11¼,	11½	11⅝	11¼
Cuba	11,	11½	11⅛	11
Do. Preference	17,	18	—	—
Direct Spanish	3½,	4	3½	—
Do. Preference	15,	15½	15⅝	15
Direct United States Cable	10⅛,	10⅜	10 7-16	10
Eastern Telegraph	11½,	11¾	11¾	11¼
Do. 6 per Cent. Preference	13½,	13¾	13¾	13¼
Do. 5 per Cent. Debentures, 1899	104,	107	—	—
Eastern Extension	12⅛,	12⅜	12 5-16	12 1-16
German Union	9¾,	10¼	10	—
Globe Telegraph and Trust	7,	7¼	7 5-16	7 1-16
Do. Preference	12⅝,	12⅞	12 13-16	12⅝
Great Northern	13½,	13¾	—	—
Indo-European	32,	33	32½	—
Reuter's	8,	8½	8	—
Submarine	170,	180	—	—
West India and Panama	⅞,	1⅛	15-16	—
Do. 1st Preference	7½,	8	7⅝	7¼
Western Brazilian	6¾,	7¼	7 1-16	6¾
Western Union 7 per Cent. 1st Mortgage	123,	125	—	—
Do. 6 per Cent. Sterling Bonds	100,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	5-16,	7-16	⅜	—
Oriental	⅛,	⅜	¼	—
United Telephone	13½,	14	14	13 7-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1⅜,	1⅝	1⅜	—
Do. (fully paid)	2½,	3	—	—
Hammond Light (£3 15s. paid)	⅛,	⅜	—	—
Swan	—	—	—	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	33¾,	34¼	34¼	33¾
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23½	23½

TRAFFIC RECEIPTS FOR SEPTEMBER, 1884.

COMPANIES.	Sept., 1884.	Sept., 1883.	Increase.	Decrease.
Cuba Submarine	2,150	2,515	—	365
Direct Spanish Telegraph	—	—	—	—
Direct United States	—	—	—	—
Eastern Extension	41,590	39,576	2,014	—
Eastern Telegraph	50,913	42,778	8,135	—
Great Northern	—	—	—	—
Submarine	—	—	—	—
West Coast of America	—	—	—	—

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NOTES.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 3rd inst. amounted to £3,409.

BOOKS.—Messrs. Crosby Lockwood and Co.'s new catalogue contains the titles of numerous books (published by that firm) suited to electrical and general engineers.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of September are £1,619, against £1,710 in the corresponding period of last year.

ELECTRIC LIGHT AT THE MANSION HOUSE.—We learn that negotiations are going on for entirely lighting the Mansion House by electric light, at the suggestion of the Lord Mayor-elect.

PROFESSOR HUXLEY.—It is announced that Professor Huxley, who is suffering from the effects of overwork, has been ordered to the South of Europe for some months of absolute repose.

PERSONAL.—We hear that the works of the Signal Engineering Company have been bought by Messrs. Gillett and Harry, who intend carrying on the business of electrical engineers at 181, High Holborn, London, W.C.

PRICE LISTS.—Messrs. Paterson and Cooper send us a copy of their new price list, which contains information upon matters relating to electric lighting. The catalogue relates principally to the apparatus constructed by the firm.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 10th October, were £2,592, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

CIRCUS, LIVERPOOL.—Messrs. Cooke Brothers' new circus at Liverpool is to be illuminated by the electric light. The order for the necessary work has been placed in the hands of Mr. F. D'A. Goold, electrical engineer and contractor, Arcade-chambers, St. Mary's Gate, Manchester.

POPULAR FALLACIES AS TO LIGHTNING.—That chewing the splinters from a tree struck by lightning will cure the toothache; that such splinters will not burn; that the bodies of those killed by the lightning shock do not become corrupt; and that no one is killed by lightning while asleep.

CHICAGO.—The trunk lines of the Chicago Fire-Alarm Telegraph have been placed underground in La Salle and Washington Streets, and the underground system will be extended as fast as possible. It is thought that the entire cost of putting police and fire-wire plant underground will be about 150,000dols.

A NEW ACCUMULATOR.—M. Parod has invented an accumulator, which differs from Planté's in having a copper plate, covered with lead, so as to be hermetically closed. By means of this copper core the primary current reaches all the secondary plates simultaneously, so that all the parts develop an equal electro-chemical activity.

IMPROVEMENT IN THE MICROPHONE.—M. Vandenberghe has secured a patent from the Belgian Government for improvements in microphones, especially the Ader instrument, which dispenses with the call push and one of the batteries, substituting an arrangement which keeps the call bell ringing until the receiver is taken off its hook.

TRANSMISSION OF CURRENT TO A DISTANCE.—An electric current, capable of maintaining distinct groups of lamps, has been transmitted from Turin to Lanzo, a distance of 40 kilometres, or 25 miles. Gaulard and Gibbs secondary generators, with two 3-millimetre bronze wires (one for return), were used, and the experiment is said to have been perfectly successful.

TROUVÉ'S ELECTRIC LAMP.—The energetic Trouvé, who, having "found," continues to find, and will probably go on doing so for the term of his natural life, has now introduced a regulator of current intensity into his system of safe electric lighting and automatic extinction. He has also devised a new type of lamp specially adapted to domestic lighting.

UNITS OF POWER AND WORK.—In the last number of *L'Electricien*, M. E. Hospitalier demonstrates that it is as incorrect to express work in *watts*, as power in *kilogrammètres* (1 kilogrammetre = 7·23 foot-pounds), and he hopes that Messrs. Rothen and Rousseau will modify their definitions, so as to accord with the exact signification of the new mechanical and electrical units.

PRIME MERIDIAN.—The International Conference has at length come to a decision; and the time of Greenwich was definitely adopted as the First Meridian. The representatives of France, who at first stoutly opposed this choice, finally abstained from voting either way. On Wednesday the Conference carried a resolution proposing the adoption of a "universal day."

ELECTRIC LIGHT IN LIBRARIES. — In reproducing our note on the electric light at the British Museum, the *Annales de l'Electricité* advises the authorities of the Royal Library, Brussels, to satisfy themselves as to the steadiness of the light, with a view, we suppose, of adopting it. Seeing that the library in question closes at the early hour of four, this would be a highly judicious step.

INDUCTION ELECTRIC LAMP.—In Belgium M. Delaurier has patented an electric lamp, in which a hammer, carrying one of the carbons, receives a rapid reciprocating motion from a coil, through which the intermittent current of one or more battery cells is made to pass. The sparks caused by the alternate contact and separation of the carbons produce upon the retina of the eye the effect of a continuous light.

SIXPENNY TELEGRAMS.—With the view of meeting the great addition of business anticipated when the sixpenny rate for telegrams comes into operation, four wires are being added to the west coast system between England and Glasgow, these being in addition to those recently put on. During the last three or four years the means of telegraphic communication by this route have been more than doubled.—*Pall Mall Gazette.*

THE GLOBE TELEGRAPH AND TRUST COMPANY.—The directors, at the board meeting held on Tuesday, declared the payment of an interim dividend on and after the 24th inst. of three shillings per share on the preference shares, less income tax at fivepence in the pound, and of two shillings per share on the ordinary shares, free of income tax, for the quarter ending the 18th inst. The transfer books were ordered to be closed from the 15th to the 24th inst., both days inclusive.

ANGLO-AMERICAN TELEGRAPH COMPANY.—The Board of Directors have resolved, after placing the quarterly sum of £37,500 to the renewal fund, to declare an interim dividend for the quarter ending 30th September, 1884, of 15s. per cent. on the ordinary stock, and 30s. per cent. on the preferred

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stock, payable on the 1st November to the stockholders registered on the books of the Company on the 30th September, 1884.

Electric Communication in Railway Trains.—Messrs. Collingwood and Mortin have devised an arrangement for establishing all the electrical communications necessary in a train, for signalling, lighting, &c., without its being necessary to establish connections when making up a train. The contacts are attached to the springs, rest on the axle-boxes, and carry rods, which remain in electrical communication without the necessity for any coupling up.

Gas and Electricity.—Mr. F. D'A. Goold, electrical engineer and contractor, Manchester, has been favoured by the Manchester Corporation with instructions for the lighting of their New Victoria Hotel by electricity. The installation will comprise both arc and incandescent lamps. It is not often that we have the pleasure of recording the fact of an order being given for electric lighting upon such a large scale by gas owners to their rival—electricity.

The Late Accident at the Health Exhibition.—Our contemporary, the *Bulletin*, falls into error when it says that the unfortunate man killed by a Hochhaussen dynamo was "*foudroyé*," that is, struck as if by lightning. Such is not the case, for he lived fully ten minutes after the shock. Some of our English contemporaries still persist in saying that the accident happened during the operation of oiling, whereas it was proved that Pink had not even an oil can in his hand.

Extension of the Telephone in Europe.—In London, of the 3,350 telephone subscribers, 785, or 25 per cent., were enrolled during the last year; and in Manchester and Liverpool 475, or 17 per cent., out of 2,734. In France the increase is 15 per cent., or 796 out of 5,535; and in Belgium, 9 per cent. in 6½ months, or 194 out of 2,284. In Italy, from a total of 5,301 subscribers (not including Turin and Genoa), 1,591, or 30 per cent., have been added during the last 13 months.

Electric Light at the Healtheries and Fisheries.—The *Bulletin des Téléphones* says that the Health Exhibition has been a veritable success for the electric light, which almost exclusively supplies the illumination of the buildings; that the installation was better organised than at the Fisheries last year; and that the various systems of this the most extensive application of the electric light ever made in England were arranged so as to set forth to advantage their respective merits.

Not Quite O. K.—The New York *Telegram* says of the Newport electric lights:—"Whenever the moon ought to shine, then it is supposed to shine, and the lights are turned out, and the greater part of the city left in darkness. If a dense fog should roll in and obscure the moon, or a heavy rain storm take place, and make everything of an inky blackness, then that, as they say in the law, is the 'act of God,' and it would be flying in the face of Providence to have light where He means darkness to prevail."

Intercommunication on Railway Trains.—A French Ministerial circular, dated 15th April, 1884, obliges railway companies to provide means of communication between passengers and guard in all express trains or those running 25 kilometeres (15½ miles) or upwards without stopping; and a sign, preferably outside the carriages, must indicate the compartment whence the signal has proceeded, without its being possible for the passengers to suppress the indication. This is to be carried into effect by 1st July, 1885.

Careless Writing.—This is the title of an article, reprinted from the *Penman's Art Journal*, in the *Telegraphers' Advocate*, a New York journal having aims somewhat similar to those of its contemporary, *The Operator*. The article referred to shows how easily carelessly written words may be taken for other words, giving examples of good or bad writing. In writing a message for telegraphic despatch, care in the formation of the letters should always be a *sine quâ non*, as the operators have sufficient evils to contend against besides having to deal with "such outlandish and meaningless scrawls," which are a nuisance, and discreditable to their authors.

The Telephone in Italy.—The following figures give the total number of subscribers to the Italian General Telephone Company in the various towns of Italy and Sicily up to the end of August last, the figures in parentheses representing the increase during the year:—Turin, 1,140 (563); Milan, 1,087 (567); Genoa, 828 (313); Florence, 742 (221); Bologna, 436 (118); Leghorn, 317 (77); Rome, 1,351 (428); Naples, 641 (102); Venice, 190 (5); Palermo, 333 (80); Messina, 124 (11); Catania, 181 (51); totals, 7,370 (2,536). In Turin, Milan, Genoa, Florence, and Bologna amalgamations have been made during the year with competing companies.

Scientific Discoveries.—On the occasion of distributing prizes to the successful students of the Derby School of Science, the Home Secretary said that England was fortunate in being the cradle of science. No other nation could boast of a Newton, who laid the foundation of all that had since been discovered in physical force. To these great scientific discoveries and to the development of the uses that had since been found for steam, coal, iron, and electricity, England owed as much as she did to her victories on the battlefield. We must not, however, rest on our oars, and rely upon what had already been accomplished if we wish to compete with Continental nations.

New York and New Jersey Telephone Company.—The subscribers' list of this Company is before us, and makes a fair sized book. The Company has in operation a number of offices for casual customers—such offices have been advocated in London—but with perhaps the exception of the National Company, the English companies have lost touch of their customers. The English have much to learn from American and Continental managers—not, perhaps, in the matter of finance, but in the matter of obtaining and keeping customers. The telephone is rapidly becoming a necessity in every house in America, and should certainly receive as warm a support here were the conditions as favourable.

Electric Light at Llanelly.—An Art Loan Exhibition was opened in the Mechanics' Institute, Llanelly, last week, when the electric lighting, carried out by Mr. J. C. Howell, formed by no means the least of its attractions. A Crompton-Bürgin 50-light dynamo is driven by a portable engine, supplied by Mr. C. D. Phillips, of Newport, and maintains 70 lamps, a series of storage batteries serving to regulate the light. The large hall is illuminated by 34 incandescent lamps, with tinted venetian shades; and in the vestibule Mr. Tayler Smith shows some of his new domestic fittings for incandescent lamps that may be removed from, and replaced on, various "shoes" placed in the circuit, and which transmit the current to the lamps.

New Source of Indiarubber.—The attention of the Indian Government has lately been drawn to a new plant, common in southern India, which gives an abundant supply of pure caoutchouc. It belongs to the class of the *Apocynaceæ*, and is called *Prameria glandulifera*; it is a native of the forests

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of Cochin China, and its sap is often used medicinally. When the branches are broken, a large quantity of caoutchouc is seen in the interior, and can be drawn out in threads, as in the *landelphia* of eastern Africa. The plant may be propagated from young shoots; and M. Pierre, director of the botanical garden of Saigon, thinks that it can be transplanted until it is about ten years old, and that it may constitute an addition of great value to the forest products of India.

ELECTRIC LIGHT IN HUNGARY.—With respect to our note bearing this heading, in *The Electrician* of the 4th instant, the information of which was obtained from the *Standard's* correspondent at Buda-Pesth, we have received some further particulars, by which it appears that though the dynamos are of the Brush type, the lighting is effected by incandescent lamps. Temesvár is the town of third importance in Hungary; and although the plant is put down for permanent illumination, it is not at present in regular operation, the trials hitherto having merely the object of ensuring everything being in a satisfactory condition for the official opening in a few weeks' time. The work has been carried out by the International Electric Company (Limited), whose general office is in the Getreidmarkt, Vienna.

THE APPROACHING TELEGRAPH CONFERENCE.—The following letter from Mr. Lewis Wells, secretary to the Joint Committee of the Submarine Cable Administrations, appeared in *The Times* of Oct. 8, in reply to the letter of Mr. Meyer, given in our last issue:—"In *The Times* of the 6th inst. there is a letter from Mr. Meyer, of Liverpool, respecting the approaching Telegraph Conference, in which he says 'he is given to understand that a strong effort is to be made by the cable companies to reduce the limit for code words from ten letters to eight,' &c. I shall be glad if you will contradict this statement, which is incorrect. It is not the intention of the cable companies at the approaching conference to propose an alteration of the present rules or method of counting which would have the effect of enhancing the cost of telegrams."

COTTON COVERING OF DYNAMO LEADS.—Herr Uppenborn, of the *Centralblatt für Elektrotechnik*, has investigated the rules to be followed in making the wires which serve for the conductors of dynamo-electric machines. With regard to their insulation, he advises a double covering of cotton threads, coated outside with spirit varnish. The special object of the insulating substance is to prevent contact between the wires. The cotton covering should not, therefore, be thicker than is strictly necessary for preventing an exposure of the metal when the wire is bent. This is secured by adopting the following thicknesses of cotton covering for the respective diameters of wire:—1 mm. and under of wire, 0·5 mm. of covering, 2 and 3 mm. (0·6 mm.), 4 mm. (0·7 mm.), 5 mm. (0·8 mm.), 6 and 7 mm. (0·9 mm.), 8 mm. (1 mm.), 9 and 10mm. (1·1 mm.).

TISSANDIER STEERING BALLOON.—The following is, according to the inventors, MM. Tissandier, an exact description of the most distinctive portion of their new balloon, that is to say, the helm:—"This organ, made of glazed calico, is placed at the hindermost point, whence it projects considerably. It is divided into two distinct portions. About half its surface is kept rigid, and constitutes the keel of the aerial vessel, while the rudder proper, which forms an addition to the keel, may be inclined to the right or left, so as to determine, when the propeller is revolving, a corresponding movement of the whole apparatus. The rudder and the keel, stretched by cords, are mounted on a bamboo frame connected on one side with the longitudinal shafts (*brancards*) of the balloon, and on the other with a strong piece of walnut wood fixed below the propeller to the lower portion of the car."

THE INTERNATIONAL INVENTIONS EXHIBITION, 1885.—With reference to this forthcoming exhibition, Messrs. Henry Milward and Sons, of Redditch, suggest that there is ample room for an attractive and useful exhibition upon parallel lines to this, viz., the exhibition of those inventions which have hitherto met with no market. "To judge by the letters and offers we receive in our particular industry, there are hundreds, nay thousands, of inventors, with clever and striking machines, and articles of general usefulness, who are unable to *exploit* their inventions for want of capital or for want of publicity. To this class an exhibition of inventions would be a real boon, and a national and an international object would be served by enabling them to see the light. With the addition of manufactured articles which are the subjects of patents, and of music in all its varied forms, an exhibition commanding all the elements of success would be insured.

THE ELECTRIC LIGHT AND THE FRANCHISE BILL.—On Saturday last a demonstration in favour of the Frenchise Bill was carried out at Perth, when amongst other models, &c., in the procession (which numbered over 6,000) there was a lorry fitted up with a complete installation of incandescent electric light. There was a vertical steam boiler working at 50lb., driving a small engine, double cylinder, 3in. by 6½in., running 300 revolutions per minute, driving a Phœnix dynamo at 1,300 revolutions, supplying current to 16 Woodhouse and Rawson 100 volt 20 candle-power lamps. The engine was designed and built by Mr. Albert Pullar, and the whole apparatus arranged by the *employés* of the Messrs. Pullar and Sons. Shining from amongst the evergreens, the lights looked very pretty, and worked most successfully over the whole length of the route, which was between two and three miles. This, we believe, is the first time such a display has been made.

THE FIRST TELEGRAPHIC INSTRUMENT.—At the Electrical Exhibition, a large display of models from the Patent Office, under the charge of Mr. J. M. Churchill, are exhibited. Among the two hundred and fifty pieces, is the original Morse telegraphic apparatus, patented April 11, 1846. The transmitter is mounted on a pine block, and is very crude. The armatures are wound with very coarse and poorly insulated wire, and the sounder consists of an ordinary piece of stick, which strikes against a piece of iron. The clockwork which operates the cylinder, about which the perforated paper was wrapped, is of a more improved pattern. On the card attached to the exhibit is the following, said to be an effusion of a clerk at the Washington office:

"The steed called Lightning, says the Fates,
Was tamed in the United States.
'Twas Franklin's hand that caught that horse
That was harnessed by Professor Morse."

—*Scientific American.*

TRAMWAY WORKED BY ELECTRICITY.—The Alps Hotel at Chillon has been connected by a tramway with the Mont Fleury Hotel, which is situated above it, at a vertical distance of 180 metres (590ft.). Some trials have been made on a gradient of 1 in 3⅓, with a ½-metre gauge, for a length of 50 metres. Between the rails is a strong rack; and the car carries a dynamo, which puts in motion a spur-wheel gearing with it. An ordinary brake, supplemented by an electric brake, permits of regulating the speed. During the trials, the 5 horse-power dynamo was driven by a portable engine; but for definite working it is intended to use a turbine, as water is abundant. The current is led by copper cables laid between the rails by the side of the central rack, and against which rub

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the collectors of the dynamo. The car, weighing from 300 to 500 kilograms (6 to 10 cwt.), is capable of carrying three and even four persons, at the rate of 1 to 2 metres per second.—*Centralblatt für Electrotechnik.*

GAMBLING BY TELEGRAPH.—Mr. H. P. Gurney, of Cambridge, writes to *The Times* as follows:—"Sir: It is hardly surprising that gambling is permitted in railway carriages while special facilities are afforded to gamblers by the Post-master-General. It is notorious that betting telegrams are allowed to be freely sent through the Post Office wires. Gamblers are allowed the benefit of the reduced rates offered to Press telegrams. At all great races public servants are officially employed at the public expense to make every possible arrangement to facilitate gambling. Betting is forbidden by Act of Parliament in any public place. Wagering has blasted many a promising career, and brought ruin and misery into many a happy home. The convenience of sixpenny telegrams is withheld on the ground that the Department has already as much business as it can undertake. Sir, I beg your powerful advocacy to protest against this wanton and wicked prostitution of a great public monopoly to the injury of morality, in defiance to the expressed wishes of the nation."

TELEPHONIC SYNCHRONIZATION.—A marine chronometer is placed in a cabinet, 21 cm. wide, 31 cm. deep, and 28 cm. high, attached to the walls of the Berlin magnetic observatory. The cover and two faces of the cabinet are made of looking glass, which resounds well. The microphone is placed against the door opposite the wall, and permits of distinguishing the beating of the chronometer more distinctly than if it be placed to the ear. The chronometer beats the half-second, and is regulated by the mean time, while the clock beats the second, and indicates the astronomical time. Consequently the interval which separates two coincidences is 3 min. 2½ sec. of mean time, or 3 sec. of astronomical time. The observer perceives through the cover the hour shown by the dial, the beating of the chronometer, and that of the astronomical clock. The correction is therefore made by taking as a starting point the interval between two coincidences. Daily and repeated experiments have proved that the irregularities of the chronometer are much more important than the probable errors caused by delay due to the telephonic transmission.—*Centralblatt für Elektrotechnik.*

THE ELECTRICAL WORKING OF UNDERGROUND RAILWAYS.—*Apropos* of the Paris Metropolitan Railway, which it appears is about to be conceded to a syndicate patronised by the Northern Company, the *Bulletin de la Compagnie Internationale des Téléphones* observes very justly that the occasion is a capital one for trying electrical traction. Hot air or compressed air locomotives would not be sufficiently powerful, unless of excessive size and weight; and we are persuaded that the Parisians would never stand the disgusting atmosphere that Londoners put up with in their sewer line. Our contemporary thinks that the experiments that are being arranged at Creil, connected with the transmission of current for a long distance, will come in most opportunely in view of solving the question of underground traction. The *Bulletin* speaks of having lately seen the *locomotives* for supplying the current already *en marche*, and only waiting for the generating machine and the leads for transmitting to Paris the current, which will supply two or three receivers. But does not our contemporary mean rather *locomobiles*—that is to say, portable engines, rather than *locomotives?*

TECHNICAL ELECTRICITY AT OWENS COLLEGE.—The class in technical electricity, under the direction of Professor A. Schuster, F.R.S., commenced its third session last Thursday evening (October 16th). The class meets for two hours, one hour being devoted to lecture and one hour to laboratory work. The lectures deal with the leading scientific principles of electricity and their direct technical applications. In the laboratory elementary students commence with the construction of a mirror galvanometer, a Wheatstone bridge, a standard resistance coil, and a Daniell cell. All materials being provided, the student is required to put them together and to make simple tests with the constructed apparatus. Afterwards the student proceeds to a course of electrical measurements with the apparatus provided in the physical laboratory. This course includes testing for faults and the chief measurements relating to the strong currents used in electric lighting. Arrangements will also be made this session so that former and advanced students may devote nearly the whole of their time to work in the laboratory, which will be occasionally supplemented by short special lectures relating to practical work.

THE LATE PANIC ON THE NEW YORK STOCK EXCHANGE AND THE TELEGRAPH.—At the meeting of the Institute of Bankers, held on the evening of the 15th inst., a paper was read by Mr. Robert W. Barnett on the action of the New York Clearing House Association during the recent crisis, in which he alluded to the rapid subsidence of the panic. In the discussion which followed, Mr. L. Handard (manager to Messrs. Martins) said he thought the rapid manner in which the panic had subsided might be attributed to a large extent to the telegraph. It was known that large sums were ordered to be remitted by telegraphic transfers, not only from London, but also from various cities in America to New York. This money was to be lent out at the very high rates of interest which could be obtained at the time, or to be used for purchasing stocks at the very low prices then quoted on the Stock Exchange. All this, he considered, had helped to make the panic of so much shorter duration than previously, or of panics which occurred before the establishment of the different cables. He thought the lesson to be derived from this was that when we had a panic here it would not be of the same duration as former ones.

ELECTRIC MOTORS AT THE PARIS HOTEL DE VILLE.—The ventilators for the various halls and rooms of the Hôtel de Ville, Paris, are a considerable distance apart, and, instead of a motor for driving each separately, it has been decided to generate sufficient current at a central station to work an electric motor in connection with each ventilator. The Compagnie Electrique put down the plant, including two double-wound No. 6 Gramme dynamos, each absorbing about 4 horse-power. These latter maintain five separate circuits, on which are placed the different motors, working together or separately, according to requirements. They may even, in some cases, be substituted one for another. They run at 1,250 revolutions a minute, each giving out 50 amperes, with an E.M.F. of 110 volts. The electric motors which drive the ventilators are also Gramme machines, all of the No. 3 size, for convenience. Their resistance has been determined by the work which each has to do, and they make 1,450 to 1,780 revolutions per minute. Some of the electric motors are as much as 150 metres from the generators. There are 35 ventilators, requiring from 40 to 80 kilogrammètres, or 290 to 580 foot-pounds to actuate, and two 15 horse-power steam engines drive the electric generators, besides doing other work.

TELEGRAPHIC EXTENSION.—Some time ago the Scottish Fishery Board entered into communication with the Post-master-General with the view of having the telegraph extended

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to a number of remote fishery districts; and arrangements have now been concluded under which such extension has been made to several of these outlying places. They are Castle Bay, Barra; St. Margaret's Hope, Burra; St. Mary's, Orkney; Walls and Reawick, Shetland. In connection with this matter it may be stated that it is all important, in prosecuting the herring fishery, that means should exist for communicating at once to the different fishing stations the places where shoals of herrings appear, in order that fishermen may remove to these localities with all despatch; and also where there is a heavy and unexpected catch of herrings, it is most desirable to have a supply of salt and barrels as quickly as possible on the spot. It is only by the increase of telegraph stations that these advantages can be obtained. As an illustration of the benefits to be thus realised, it may be stated that recently, in the Orkney Islands, when there was little or no fishing going on in the south isles, the fishermen there got information by telegram that herrings had appeared in large numbers in the fishing grounds upon the north isles, and proceeding there landed in one week £1,800 worth of fish.

THE FUTURE OF ELECTRICITY AND GAS.—*Chambers's Journal*, in an article upon this subject, says:—"That the electric light has not proved a failure may be gleaned from a rough survey of what has been done during the past two years, in spite of unmerited depression and depreciation. In this country, permanent installations have been established at several theatres in London and the provinces; the Royal Courts of Justice, the Houses of Parliament, Buckingham Palace, Windsor Castle, the Bank of England, and other well-known buildings; while numerous railway stations, hotels, clubs, factories, and private mansions throughout the country have also adopted the new light either entirely or in part. In addition to this, over forty steamships have been fitted with the electric light during the past year; and the Holborn Viaduct, with its shops and buildings, has been lighted without interruption for the past two years. On the Continent, in addition to a large nnmber of factories, private houses, and public buildings, numerous theatres at Paris, Munich, Stuttgart, Brunn, Vienna, Berlin, Prague, and Milan have been electrically lighted. In New York an installation of ten thousand lights has been successfully running for the last year or two. Any one wishing to see the electric light to advantage, and its suitability to interior decoration, should visit the Holborn Restaurant. This building, with its finely decorated rooms, its architectural beauties, and ornamental designs in the renaissance style, when viewed by the electric light, is without doubt one of the chief sights of London."

THE TELEGRAPH CONFERENCE AND CABLES TO AUSTRALIA.—A letter in *The Times*, Oct. 1, signed "J. H. H.," discussed somewhat the charges to Australia, the errors which sometimes arise in cable messages, and the laying of a cable *viâ* the Cape, Mauritius, &c. Upon these subjects Sir James Anderson wrote to *The Times*, Oct. 9, as follows:—"Sir: Will you kindly allow me space to correct a statement made by 'J. H. H.' in *The Times* of the 8th inst.? 'J. H. H.' says 'No doubt Sir James Anderson will say it is impossible to lay a cable by the Cape to Australia.' I have never said and would not say anything of the kind. What I have said is, that where there is a long stretch of stormy ocean, with winds almost constantly prevailing in one direction, which is characteristic of the track between the Cape, Mauritius, and Australia, and where there is seldom any calm weather such as we can depend upon in the summer months in the Atlantic, and added to this where there are very great depths of water, then, under these conditions, it must always be at best very costly and next to impossible to effect repairs. The interruptions would be of very long duration, and every cable is liable to interruptions from causes known and unknown. No cable, in my opinion, should be laid unless the maintenance can be relied upon at a reasonable cost and repairs effected within a reasonable time. The 12,000 miles 'J. H. H.' estimates would only give one cable, and it would have to compete with existing and duplicated lines. It could not, therefore, obtain all the traffic, and if it did it would not pay 5 per cent. with the necessary maintenance, reserve fund, and working expenses. But 'J. H. H.' knows as well as I do that we have studied the question for years with abundant data, and that if the companies could see their way to adopt tariffs which would increase traffic without serious loss to their existing revenues they would be only too glad to do so. The allegation that the Press are spending £20,000 per annum was true in 1878, but in 1879 we reduced the tariff from 10s. 8d. to 6s. 5d. per word, the result being a falling off of more than 50 per cent. in the number of words. The traffic, however, gradually increased, until in 1883 there was an increase of 11 per cent. in the number of words transmitted, but a loss of £6,000 of revenue as compared with 1878."

SELF-INDUCTION IN ALTERNATE-CURRENT MACHINES.—The following are the conclusions at which M. E. Hospitalier arrives in an article on this subject, in *L'Electricien* of 1st inst:—The coefficient of self-induction of the circuit, both external and internal, plays an important part in alternate-current machines; and all the efforts of constructors should be directed to reduce it as much as possible. This result would be attained, in the external circuit, by using straight wires and always bringing the conductor and the return wire as near together as possible. Twists and spirals should be carefully avoided, as they increase the coefficient of self-induction in the external circuit, and tend to weaken the current, while at the same time needlessly increasing the expense. In the internal circuit an endeavour should be made to diminish the coefficient of self-induction by reducing to a minimum the length of wire necessary—that is to say, by employing intense, contracted, and high-velocity fields. From these different points of view, the Ferranti machine has made a distinct step in advance, and is beginning to find imitators. The iron cores, supposed to be necessary in certain machines, for concentrating the magnetic fields and increasing the electromotive force, should disappear, to give place to means which attain the same object, without introducing disturbances due to an increased self-induction and the creation of intense Foucault currents. In some machines, such as that of Gramme, for instance, the soft-iron armature of the induced (*l'induit*) is necessary for protecting the external portion of the wire from the action of the field, and for destroying the electromotive force of contrary direction which may be there developed; but this is a difficulty which it will be possible to remedy by modifying the winding and construction of the machine. The suppression of soft-iron armatures is therefore an improvement which should be introduced into all alternate-current or continuous-current machines, inasmuch as modifications in their magnetism always resolve themselves, in the long run, into a more or less considerable consumption of energy, and because an increase in the coefficient of self-induction, which is the result, is itself a fresh cause of loss. This is an established fact as regards alternate-current machines; and a future article will deal with it in connection with those of continuous current.

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OLD CABLE STORIES RETOLD.—VI.

BY F. C. WEBB.

SOME "REPAIRS" AND "RECOVERIES" IN THE MEDITERRANEAN IN 1858.

The Cagliari (or rather Chia) and Bona cable did not give results that satisfied the officers of the Mediterranean Telegraph Company and the French Government; and it was decided that we should proceed to work at it in the "Elba." We had also to pick up all the cable remains of four attempts made by Mr. Brett to lay cables from Chia to Algeria. These consisted of two pieces of heavy 6-conductor cable and two pieces of 3-conductor cable. The 6-conductor cable had been laid from shore in the sailing ship "Result" in tow to some 30 miles; then there had been a run, and the cable had to be cut. They then under-run a few miles from shore, cut, and spliced on, and paid out about 22 knots, and then had a run and cut. The 3-conductor cable, laid from the "Dutchman" steamer, had been laid to some 60 miles, when there had been a run, and cable was broken or cut. Then they under-run from shore some 20 miles, cut and spliced on, and paid out till they ran short of cable near a small island on the coast of Algeria. They then hung on for some days till the cable chafed through on the rough bottom. We had therefore to try to pick up four different sections, two of which had ends on the beach, the other two lying isolated from the shore.

The "Elba" was fitted with a picking-up machine designed by Mr. Fleeming Jenkin, under the superintendence of Messrs. Newall, Liddell, and Gordon. On March 1st we had a discussion about the machine. It was thus arranged: drum 6ft. diameter; spur-wheel, 9ft.; pinion, 2ft. 6in. Brake drum to be loose on shaft, but connected by palls to the cable drum, so that, if cable overpowered engine, pawls brought the brake into play, and as near as I recollect this was all carried out. The drum, spur gear, and brake were all between the bearings; the bow sheave was also properly fitted; and wooden buoys, designed by me and made by Cooper, of Hull, were supplied for the work, as also buoy and grapnel ropes of Manilla.

I left to take charge of the work until Mr. Liddell could come out to us, and arrived at Bona on the 2nd of June. The "Elba" arrived there on the 3rd. There was much correspondence with Government officials, and some tests that detained us there till the 5th. Whilst lying off Bona, an English tug, with a crowd of gentlemen on board, came steaming up to us, and an Englishman in his shirt sleeves dashed on board and asked us for a ton of coals, as they had run short and could not fetch Bona without them. I found in the Englishman an old friend, Mr. J. Player, a civil engineer, who, with Mr. T. Snowden, of Middlesboro', had an interest in some mines near Bona. On board the tug was M. Thalabout (the Stephenson of France), and a number of French engineers and financiers. As a slight courtesy in return for ours, M. Thalabout sent us two bottles of brandy that had been kept for seven years on the roof of his house at Marseilles. It was so superfine that we only treated ourselves to a small liqueur glass of it after dinner; but when the first bottle was exhausted we found that the steward had consumed the other in making his own nightly grog.

We arrived at Cagliari on the 6th. Mr. Liddell arrived the next day, and we started that night for Chia, and arrived there the next morning. We had with us Mr. Fleeming Jenkin, Mr. Francesi, Mr. Ternant, and Mr. Löffler. After various tests, it was determined to pick up some of the Bona cable, and on the 9th we got the end off the beach and began picking up, and picked up to 30·25 miles by the 12th, when we were in about 800 fathoms and had cut out a slight fault. We hung on till the 15th, in a fresh breeze, putting cable to rights, and then got cable aft and began paying out. We anchored with kedge when 4½ miles from shore to splice on some shore end, and again at one mile from shore, to splice on a new shore end, and then landed end. This was all the practical work we performed on the Bona cable; but we afterwards had ten days' testing from a martello tower at Chia, as I shall relate further on.

On the 16th we grappled close to shore for Brett's 6-conductor cable, got it, hove it up, and buoyed end of seaward part, and picked up shore part into three fathoms, and then cut it. Went off to Cagliari, back again next day, and made some more official tests of Bona cable, and then got end we had buoyed onboard, and began picking up. Had some difficulty in getting the slack carried away from drum. Rigged up a pulley to press on cable and keep it tight on drum, as the cable was a very stiff one, and the men could not keep it tight. We came to a splice which marked the spot where the 20 mile length began. Picked up to 14 miles, and came to a crossing of the 3-conductor cable, which we had been given to understand did not overlay it. We cut and buoyed with two nun buoys and Manilla rope, and put flag buoy near. We then went to work to get the end of the 3-conductor cable off the beach, but, after expending much labour in digging up ashore, we suddenly caught sight of it from the ship, just under us, and hove it up and cut it, and got end onboard on June 21st. We picked up to our buoys on the 6-conductor cable, and then found the 3-conductor cable we were picking up was chafed through by the thick one, and the end came on board. We then picked up 6-conductor cable again, and picked up about a mile, so as to be clear of our 3-conductor, and cut and buoyed again. This brought us to the 23rd, when we commenced dredging for the 3-conductor. Got it on 24th, cut it, buoyed sea end, and picked up short piece. Blowing too hard for work till 27th, when we picked up buoy on our 3-conductor length, and commenced picking up again. Came to splice that marked the shoremost end of the 40 mile length of 3-conductor cable in 105 fathoms. Took angles to mark position. Kinks now kept coming in at the rate of 40 to the mile. Picked up 13 miles, when cable parted (in about 600 fathoms) just as a bunch of bends and kinks came to the bows. We did not try to grapple for the rest of this section. On the 28th we grappled for the shoremost end of the 40 mile length of three conductors. Hooked it one mile outside end, cut it and buoyed shoremost end of seaward section. Picked up the one mile; back to buoy, got end up, and commenced picking up. Got forty-two kinks in two and a half miles. At seven and a half miles, cable broke at a kink in about 400 fathoms. On the 29th we got hold of buoys on the 6-conductor section we had been working at. At 7:15 p.m. came to a heavy lift. Belt got off, but the pawls prevented drum from paying out; and Mr. Fleeming Jenkin was pleased, for he had strongly insisted on the pawls, although I was against them. When we had got the belt on we gradually hove in an immense skein of cable, consisting of three bights and a loose end. We had to stop it together and coil it down just as it was, and it covered the whole floor of the main cable hold. I have no note of the exact length of this skein, but it was at the end of the section which was twenty-two knots long. On the 30th we dredged near shore for the second portion of the 6-conductor cable. Got it, cut it, and buoyed short piece, and commenced picking up seawards. We continued picking up steadily until 4 a.m. of July 2nd, when, having twenty-seven miles in, we came to a grand kinkation, evidently at the end, although in cutting some of it away to get it on board we cut the actual old end off. We had to get tackles on mast end and yard arms to get it in. A photograph of this kinkation was to be seen for several years in the shop window of Mr. R. S. Newall in the Strand. In picking up one of our buoys the ship drifted on to the boat that was unshackling the buoy, and the fluke of the anchor caught on the back a poor fellow named Oliver, who was formerly mate of the old "Monarch," and hurt him seriously. We went off to Cagliari, and the Italian doctors said no bones were broken, but they resorted to their favourite remedy—they bled him. He was ill for many weeks at Cagliari.

More tests had to be taken of the Bona cable, as its state was under dispute; and on the 7th of July I landed at Chia with Messrs. Francesi, Cavalli, and Pacetti. There was a martello tower perched up on a high promontory, and this was to be our abode. It had not been inhabited for years. The entrance was about 18 or 20 feet from the ground, and we had to procure a ladder to get in. When we went in an old owl and a falcon flew out, and we found a nest of young falcons inside. Into this tower we took provisions and some

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bedding, and stopped there altogether 10 days. I slept in the casemate the first night, but the feeling that all sorts of slimy things were dropping about from the walls caused me to move the next night on to the roof, where we always took our meals. We had rigged up a sail, and tried to keep it quiet with numerous crossings of No. 8 wire; but from the exposed position of the tower the wind generally kept it flapping about in such a furious way that we could hardly hear one another speak at times. We used to go down the grassy slope of the hill in our night gear to a little cove to bathe; but when we were coming away I noticed the dorsal fin of a shark right in this little cove, and I do not think I should have bathed if I had seen him before. We were pretty jolly, and got on very well together. I learnt some more Italian; and, by the time we left, my three Italian friends knew considerably more pieces of recitatives from Italian opera than they did before, and were constantly bursting out with them. We had the wires led up into the tower and made experiments on them every day, Mr. Liddell, Mr. France, and Mr. Löffler being at Fort Genois, near Bona, at the other end of the cable. A *procès verbal* was finally drawn up, but I do not know how matters ended. I should have mentioned that Spartivento and Chia are considered to be most deadly, unhealthy places. In fact, they used to say that Italian men-of-war would always sheer away from the land when obliged to pass near there, and it was considered fearfully dangerous to sleep ashore. Nevertheless, Mr. Liddell, and Mr. Löffler, and a whole party of men were caught ashore there one night by its coming on to blow, and had to pass the night in the open air. When they came off to the ship, all took some quinine in case of accidents, but nothing occurred. Of our party in the Chia Tower, one of the servants got the fever, but the rest of us escaped. There were certainly some nasty stagnant looking ponds near; and very likely it was the strong sea breeze that prevented Mr. Liddell's party from getting the fever.

In 1858 the Cagliari and Malta cable broke down, and I repaired it in January, 1859, in the "Elba." The fault was near Adventure Bank in 175 fathoms; but there was nothing in the case that would be of interest now, as the repair of cables of that type and lying away from others is now constantly being carried out.

THE PHILADELPHIA EXHIBITION.—IV.

(FROM OUR SPECIAL CORRESPONDENT.)

PHILADELPHIA, Oct. 3.

Argument in the great telephone suit of the Bell against the People's Telephone Company was ended yesterday, and the case is held under advisement. The exhibit of the People's Company, comprising duplicate models of Daniel Drawbaugh's inventions, can now be uncovered. They have been exceedingly well advertised heretofore by being covered. The suit itself is so interesting that a brief description of the 10,000 pages of printed testimony with the theories and arguments of counsel will probably be more appreciated by readers of *The Electrician* than a description of the exhibits themselves.

First, for Daniel Drawbaugh's story. He began to think of telephones, he says, in 1861, and as early as November 20, 1866, he had wrought out the general principles, and embodied them in crude instruments. In 1867 or 1868 he had invented an improved form of transmitter or receiver, by means of which he succeeded in transmitting articulate speech. These instruments he produced in court. They include a carbon resistance transmitter—the invention (it has been supposed) of Edison. In 1870 or 1871 he used a magneto transmitter. Drawbaugh's explanation of the reason why he had not patented or used his invention is that he was impoverished and burdened with debt, and that up to 1880 he was obliged to maintain his family by doing odd jobs of repairing, and that his devotion to telephonic researches had helped to impoverish him. In 1880 he sold one half interest in these inventions to the Klemm Telephone Company. This company, in defending the suit brought against it, declared that Drawbaugh's telephones were not infringements on the Bell Company's patents, but after Klemm had organised the People's Company, the line of defence was changed, and it was then declared that the Bell patents were invalid by reason of Drawbaugh's prior invention and use of the instruments. In support of Drawbaugh's story a great many witnesses were called. They were chiefly friends and neighbours, who had very hazy remembrances of a talking machine which they had seen or heard tell of. Few of them were able to fix dates definitely. He had, however, some witnesses who swore positively that they had seen and talked through his telephones before the date of Bell's inventions. Chance made me acquainted with two of these witnesses, who told me the same story they related in court. They fixed the date when they saw the telephone very definitely; it was, I think, in 1875—certainly before Bell's invention. A party had gone out on a fishing excursion from Harrisburg, and had camped near Drawbaugh's workshop. Hearing that the man at the shop (to them unknown) had this remarkable invention they called upon him, had it described to them, and examined and talked through it. This is pretty strong testimony; at the same time, knowing as I do the adventurous character of the witnesses, I should like to have it corroborated, especially in view of the strange silence of the inventor regarding his wonderful instrument.

The complainants (the Bell company) make a strong case against Drawbaugh. They show that he was a prolific and successful inventor; that between the time of his alleged invention of the telephone and the date of Bell's patents he took out four patents for other things, for which he received 10,000 dollars; that he owned his house, had the use of a well equipped workshop, was associated in business with wealthy men, and repeatedly exhibited his inventions at State Faire, and yet never patented, exhibited, or in any way made public his alleged invention of the telephone until a few years ago. Another strong point against Drawbaugh's claims is found in the models themselves. They are so nearly like other forms of telephones that it seems incredible that they should have been independently invented. Drawbaugh, it has been shown, visited the Centennial Exhibition, where Bell's invention was one of the chief wonders of the day, but he does not appear to have even casually mentioned his claim to priority at that time. The theory of the complainant is that Drawbaugh made the telephones immediately after reading descriptions of those made by Bell and others; that this accounts for their similarity to other forms, and also for some of the hazy testimony in support of his claims by witnesses who could not fix definite dates. Drawbaugh's other inventions are chiefly mechanical contrivances and modifications of existing inventions. He is evidently an ingenious mechanic, but there is nothing to show that he had ever made any study of the principles of sound or electricity, or that he had such knowledge as would suggest the invention or enable him to invent a telephone. It will be seen that the case is a very interesting one, and it involves enormous interests. If the Bell patents should be broken down it will open the door to the free use of the telephone to scores of waiting companies.

Another company is preparing to contest the rights of the Bell Company. This is the Globe, which has purchased the patents of a man named Antonio Meucci for a "speaking telegraph," patented in 1857. Meucci's invention has, of course, been improved since, until it is now practically the same thing as the telephones in use. Whether it was originally of any practical value I have not been able to learn. The Globe Company does not, of course, assume the aggressive. It is now trying to introduce its system, and if it should succeed or give signs of being about to succeed, the Bell Company will interfere no doubt, as with the People's Company, and another long trial will follow.

Bell, by the way, exhibits his apparatus for telephoning by means of a ray of light, instead of by wire conductor. It is represented that conversation has been carried on by this means over a distance of 500ft. By means of a suitable arrangement of reflectors and lenses a beam of light is trans-

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mitted to the diaphragm of a telephone, and thence reflected to a parabolic reflector at the distant station, where the light is concentrated upon a piece of selenium. The property of this matter, whose resistance varies with the amount of light thrown upon it, is used to control the vibrations of a receiving telephone. If now the transmitting diaphragm is made to vibrate by sound waves, the beam of light concentrated on the selenium cell will respond to the vibrations, varying the resistance of the selenium, and the vibrations of the receiving diaphragm, controlled thereby, will correspond with those of the transmitter. It is a very curious and interesting scientific toy.

The Exhibition is prospering greatly, and is likely to be a financial success. The daily attendance now reaches from 8,000 to 10,000. Sir William Thomson lectured at the Academy of Music on Monday evening on the "Wave Theory of Light," but did not create a very favourable impression as a popular lecturer. The audience was not large, and the lecture simply paid expenses.

W. Curtis Taylor is taking photographs at the Exhibition by the electric light with marked success, although his appliances are of the crudest description. There are two arc lights suspended in line between the sitter and the camera. Directly under them is a screen of transparent paper with the effect of ground glass, sloping to one side like a skylight. This screen does not extend over the full width of the room, thus permitting the direct rays of the electric lights (covered with ground glass globes) to fall upon adjustable side screens of white muslin, which are used to modify the lights on the sitter's face. The effect of this simple arrangement is that of sunlight, and the pictures could not be told even by an expert from those made by daylight in an ordinary gallery. The light is well diffused and is concentrated for effect by the side-screens, as in ordinary gallery practice.

THE CARY TELEPHONE SIGNAL.

A growing evil in the rapidly-extending electrical business is the multiplicity of wires over and under ground. Already our large cities begin to present a very unsightly appearance, and in many of them the wires, like the Scythian arrows, begin to darken the sun. Danger in case of fire is a very important consideration, and several instances have shown how great an impediment the hot falling wires are to the firemen. Heavy fixtures may in a storm be blown into the street, endangering the lives of passers. All these evils must as far as possible be remedied, and any device tending to that end should be welcome. One way of avoiding trouble is to place the wires underground. This has been made to answer for the telegraph, but thus far we have no very extended system of underground telephone wires. Invention has been exercised to make the overhead wires do more service, and this is the end sought to be attained by the Cary telephone signal. It has stood a long practical test, and thus far done its work well. It is unnecessary to say that numerous attempts have been made to find a good individual system for circuit lines, and that many devices have been tried for this purpose. Nearly all have failed in practical results, the causes being generally uncertainty of action and complex mechanism.

Mr. T. D. Lockwood, electrician, of the American Bell Telephone Company, in his book, "Practical Information for Telephonists," says: The essential points that every individual signal instrument should possess are the following:—

1. They should be able to call up the station required.

2. This must be done to the exclusion of all the other bells or stations on the line.

3. When a station is to be called on a line, and other stations are between the station calling and the station called, those between must not be rung up in passing.

4. A unison, zero, or initial point, and a method for bringing each apparatus to such point, so that all the instruments may commence each operation together.

The Cary telephone signal, which is now to be seen at 17, Devonshire-square, has these four essential qualities, and is, moreover, exceedingly simple, so that it seems almost impossible to get out of order. In addition, it shows when the line is or is not in use, and can easily be attached to any existing system of lines.

A description of the instrument, as shown by Mr. Stetson, in its essential parts follows:—

Fig. 1 shows the instrument with the cover removed. M is an electro-magnet, B a neutral armature hung on pivots, and kept

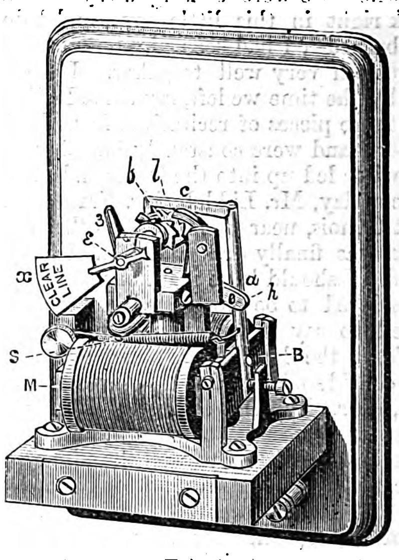


Fig. 1.

from the electro-magnet by the retractile spring *s*. The armature B has attached to its upper side the lever *a*, carrying on a pivot the notched arm *c*. *e* is a horizontal shaft, resting in standard bearings at each end. *l* is a rachet secured to the shaft *e*, arranged to be rotated step by step by means of the hooked end of the arm *c*. *f* is a ratchet secured to the shaft *e*, and

Fig. 2.

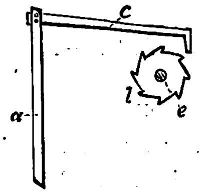
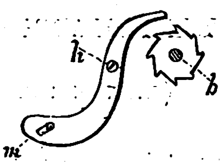


Fig. 3.



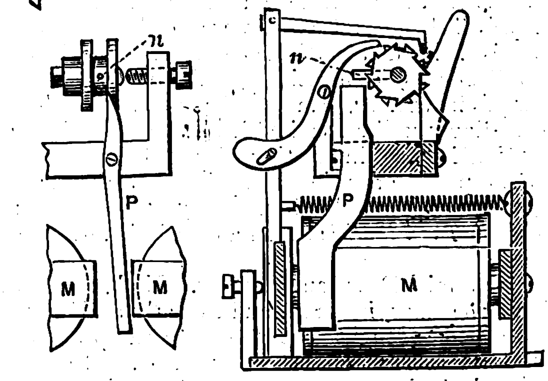


Fig. 4.

having its teeth arranged opposite in direction to the teeth of the ratchet *l*. Against the shaft *e* press two springs, one of which, shown at 3, automatically throws in the subscriber's bell, as shown in Fig. 5. *x* is a signal showing when the line is in use.

Fig. 2 shows more plainly the action of the arm *c*, and Fig. 3 the action of the pawl *h*. *m* (Fig. 3) is a slot in which slides a pin, fastened to the lever *a* (Fig. 2), so that one attraction of the magnet M moves both *a* and *h*, thereby preventing more than one step at one time.

Fig. 4 presents a side elevation of the instrument, and shows the action of the polarised armature P. P's action is as follows:—A positive current sent to line throws P to one of the poles of the magnet M. When the ratchet wheels have turned the axle around to the proper point, the polarised armature P catches in each of the instruments on the pin n, thereby preventing them from rotating further, and furnishing

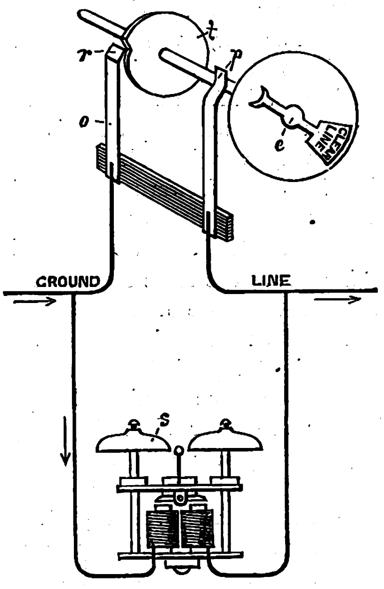


FIG. 5.

the unison point. From this unison point they are released by a current of opposite polarity.

Fig. 5 shows the manner in which the subscriber's bell is rung. Fastened to the shaft e, and revolving with it, is a wheel, t, having on its circumference a notch, r. This notch r occupies a different position on each subscriber's wheel in reference to the unison point. For instance, in subscriber No. 1's

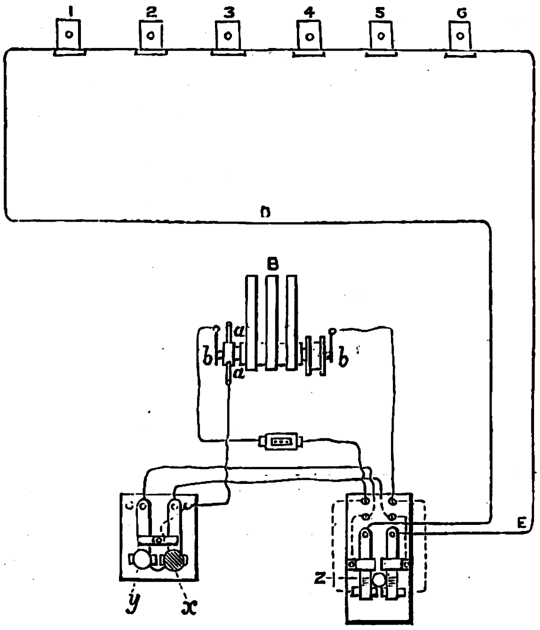


FIG. 6.

instrument one depression of the positive key in the central office brings the spring o opposite the notch r. A current now sent down the line must pass through the magneto bell s, as shown in Fig. 5. If the current be a vibratory one, it must ring the bell s. At this time all the other instruments, except the one desired to be called, are in such a position that the current's course must be line-spring o, axle e, spring p, to line, and thus only one station is disturbed. This takes place because the resistance of the axle e, and the springs p and o, is so small (except in the position shown in Fig. 5) that only a small portion of the current passes through s, much too small to cause it to ring.

Fig. 6 shows the complete connections fitted to get the two kinds of currents required—the continuous for moving the signal around, and alternating for ringing the subscribers' ring. B is the dynamo, worked by foot or power; $a\ a$ the commutator brushes giving the continuous current; $b\ b$ springs pressing against the two ends of the axle of the armature, furnishing the alternating current.

Suppose, now, No. 1 calls the central office, and desires to be put in communication with No. 4. The operator at central office presses the key x four times, turning all the instruments along four points, when No. 4's instrument is in the position shown in Fig. 5. If, now, the operator press the key Z, an alternating current is sent to line and No. 4's bell rung. It will be seen that the object arrived at is simplification and cheapening of the telephone system. A somewhat similar apparatus is that of Brown and Saunder's, as shown at the Crystal Palace Exhibition, and which has been greatly simplified since.

ELECTRIC LIGHT AT THE DAIRY SHOW.

While strolling through the gallieries of the Agricultural Hall on the closing day of the Dairy Show held last week, we could not help remarking the dejected look of the pigeons and poultry, and even of the usually cocky game fowls. The cause was not far to seek. The poor birds had been subjected during four evenings, from night-fall to past ten o'clock, not only to the products of respiration from the visitors and the animals below, but also to the foul emanations, to say nothing of abstraction of oxygen, from the numerous gas jets which illuminate the building. We could not help wondering when there is a pure wholesome light available—witness the Healtheries—that it should not be adopted. Besides, the Agricultural Hall would lend itself so readily to a comprehensive system of electric lighting. There is plenty of room for motors and dynamos. A few arc lights, judiciously disposed, would illuminate the ground floor effectually, while incandescent lamps in the bays under the galleries, and in the galleries themselves, would set off the individual exhibits, and the atmosphere would not be so vitiated as it is at present. On descending to the ground floor, we were agreeably surprised to find that a praiseworthy attempt had been made by two electric lighting companies to supply a partial illumination to individual exhibitors. The Electric Light Supply and Fitting Company, of 28, York-street, Westminster, had arranged to maintain three 2,000-candle arc lamps; but in this they were frustrated, as they could only run one of their two dynamos, owing to the portable engine they had hired falling short of their requirements. They, however, maintained a number of 55 incandescent lamps, some of which were provided with opal reflectors. Gerard's Company, of 82, Hatton-garden, maintained four of their 20-candle elongated incandescent lamps by a dynamo, driven by a small horizontal engine, and giving out 10 amperes at 35 volts.

CABLE COMPLETED.—At the moment of going to press we are informed that on the 9th inst. the ss. "International," of the Silvertown Telegraph Works, completed the laying of a cable connecting St. Vincent with St. Jago, Cape de Verde Islands.

NEW MICROPHONE.—Dr. Hipp, manager of the telegraph and electric apparatus factory at Neuchatel, has patented a microphone, which will be very useful on telephone lines. The instrument works without induction coil, and is directly connected with the telephone line. A single range of batteries at the central station is therefore sufficient for working all the stations; and there is no need of a battery in connection with the subscribers' instruments. In addition to this diminished first cost, it is said that there is a saving in maintenance, while the sounds are clear and distinct.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes ... 505
Old Cable Stories Retold.—VI. By F. C. Webb ... 510
The Philadelphia Exhibition. IV. ... 511
The Cary Telephone Signal. Illustrated ... 512
Electric Light at the Dairy Show ... 513
International Patent Rights ... 514
Correspondence ... 515 and 516
Electricity at the Antwerp Exhibition, 1885 ... 516
The Theory of the Dynamo-Electric Machine. By Professor Rowland. Illustrated. 516
An Electrical System for Coast Defence. Illustrated ... 518
Justice to All ... 520
Electric Lighting from a Sanitary Point of View ... 520
Companies' Meetings—
The Eastern Extension, Australasia, and China Telegraph Company ... 522
The West India and Panama Telegraph Company ... 524
The Telephone Company of Ireland ... 524
Companies' Share List ... 524
Telegraph Traffic Receipts for September, 1884 ... 524

INTERNATIONAL PATENT RIGHTS.

Some correspondence which is appearing in *The Times* relating to the International Exhibition of Inventions to be held in London next year has no doubt awakened misgivings in the minds of intending exhibitors. It is feared that in the present state of the laws relating to patented inventions severally prevailing in the various countries which may be expected to contribute to the show, and which in any case will be certain to swell the number of foreign visitors to inspect what is to be seen there, that the moral rights of exhibitors to proprietorship in their products, processes, or inventions, will not be so religiously respected as could be wished; and that, in short, the display will afford a grand opportunity for foreigners to appropriate free of charge, and export free of duty, ideas which are not legally or morally their own.

In one sense the proceeding here deprecated is in reality one of the, at least, ostensible objects of all such exhibitions. They are got up with the avowed aim to spread information, to help one set of people to learn something from another set of people, to encourage ingenuity by showing what ingenuity has already accomplished, to stimulate improvements by showing where improvements are wanted, and generally to help on the inventive faculty for the good of mankind. These are the ideal objects; and for the purpose of the present discussion we may leave out of account all lower or less disinterested motives. What, however, holds good for the country in which the exhibition takes place, holds also for the other countries which patronise it; and it would be impossible to open any exhibition of the kind if free access to every corner of it were restricted for fear of foreign piracy. It would be a narrow, insular, and selfish view to take of these exhibitions —which are now becoming common in every capital of the civilised world—that they are to benefit only the country in which they are held. It is, moreover, an impracticable view, and therefore no more need be said about it.

But it must be granted that the fears which have found expression in *The Times* are not wholly without foundation. So far as there is real danger, however, every inventor may be trusted to guard his own property in the way he thinks best. Some will no doubt abstain from open exhibition, and nobody can blame them; but the necessity for this extreme caution must, we think, be very rare indeed, and we strongly deprecate the alarmist views put forward by *The Times'* correspondents. For one chance they risk of illegitimate piracy they may lose by abstention a dozen chances of legitimate trade.

The risk which actually has to be run at these international gatherings is due to the absence of any complete international understanding as to the rights of patentees. There are still one or two countries in Europe that have no patent laws at all; and of course there are some outside Europe whose newly awakened industries are ever alert in adopting, without acknowledgment, the superior appliances of heathens who believe in patents. But, broadly speaking, the world in general is agreed that some form of protection should be accorded to the man who invents a thing or a process that is at once useful and new. No universal agreement is to be expected yet awhile on the nature and duration of this protection, nor can we ever hope that exactly similar views will obtain as to what is entitled to protection and what is not. In some countries—in Germany, for example—it is difficult to obtain protection; in others, for example in England, it is now perhaps too easy. But there ought to be no disagreement as to the rights of protected inventions as between one nation and another. The punishment for theft may be heavier in one country than in another, and their definition of the crime may even differ materially; but the laws of extradition between civilised nations are framed on the basis that for what one nation holds to be a crime the other will yield up the criminal on proof of his having committed it.

Apart from certain niceties this rule prevails very generally, and the tendency is towards uniformity. We see no reason why similar principles should not apply to international industrial law. A great stride has been taken, we are glad to notify, in this direction by the International Convention for the Protection of Industrial Property, signed at Paris in March, 1883. To this Convention Her Majesty's Government, somewhat tardily, gave in their adhesion a few months ago; and it now includes France, Belgium, Italy, Spain, Portugal, Holland, Switzerland, Servia, Brazil, and one or two South American Republics. The adhesion of Germany, Austria, Russia, and the United States is still wanting, but not for long it may be hoped; and meanwhile the attention of inventors may properly be drawn to the provisions of this Convention—a copy of which may be obtained of Hansard at the small cost of twopence—and to the fact, in view of the forthcoming Exhibition, that in respect to certain countries the English patentee is perfectly safe, whilst he is not so safe in respect to certain other countries. The general scope of this international agreement is sufficiently indicated in Art. II., which declares that "the subjects or citizens of each of the contracting States shall, in all the other States, as regards patents, industrial designs or models, trade marks and trade names, enjoy the advantages that their respective laws now grant, or shall hereafter grant to their own subjects or citizens." One useful provision relieves the inventor from the necessity of simultaneous patenting in

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foreign countries, six months' grace being allowed, during which period the inventor possesses prior claims in all the countries embraced by the Convention. Temporary protection is also given to patentable inventions exhibited at officially recognised International Exhibitions.

It should be the business of inventors to get this most valuable Convention extended to the rest of the great industrial nations of the world as speedily as possible. Meanwhile, however, we have very little doubt as to the point of English law raised by our correspondent "A. F." A patent in this country, whatever it may do in Germany, concedes the exclusive privilege to "make, use, and vend;" a privilege which, we take it, excludes the importation of the same article made in another country to be sold and used in this. The question may arise whether the article *is* the same, but that is one on which the patentee can set the law in motion to decide. When there is no doubt on this point, imported infringements of patents are liable to confiscation; and as a matter of fact such confiscations at the port of landing are by no means infrequent. It is a rule of this kind which is to be desired for all countries in the interests of inventors, and which is secured to a considerable though still only partial extent by the Paris Convention

CORRESPONDENCE.

A "NEW" FORM OF ELECTRO-MAGNET.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your "Notes," p. 466, is mentioned a form of electro-magnet which is credited to Signor Ricco, of Palermo, and which form you mention has been in use for some years in this country. The mere fact that I devised and made for my own use this type of magnet 30 years ago would not entitle me to claim them; however, the fact that they were devised as a necessary consequence of the theory of magnetism explained in my "Electricity" gives me a better title to their paternity. They were, in fact, deliberately made, not on a guess or experiment, but because I saw that an iron conductor carrying a current must become a magnet and require no separate core. However, my best title to the device is that it is fully described in my patent, No. 4,762, of 1878, and applied to dynamo machines for the express purpose of generating and utilising the so-called "Foucault currents," instead of trying as usual to prevent their formation. I have also used the principle in making electro-magnets for other uses, though it is not often that they will have any advantage over the usual form of construction when it is the magnetic force or field that we have to utilise.—Yours, &c.,

J. T. SPRAGUE.

[We have a strong impression that we have read of similar magnets being used in America by Henry and others even earlier than the time mentioned by Mr. Sprague.—ED. *E.*]

A CURIOUS CASE OF INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Whilst testing the Blake transmitters which are manufactured by the American Telephone Company, I discovered a curious case of, I believe, induction. I had just laid my receiver on the shelf to which the transmitters are affixed so as to adjust the switch spring of the magneto call bell. I had occasion to put my ear rather close to the instrument, and I was surprised to hear the men talking at the other end of the line. I then hung my receiver on the switch hook, and placed my ear again against the instrument. I still heard the same voices. After this I summoned a man to talk and whistle very close to the instrument, whose voice (the man's) I heard very faint but very distinctly. I then placed a small piece of paper between the platinum spring and the carbon button of the transmitter, with the result that I could not hear the man's voice at all, but as soon as I took the piece of paper out I could again hear him talking. If any of you will explain this to me I shall be very much obliged. Will you insert this in your next issue? F. L. C.

London, October 13th.

THE USE OF TELEPHONES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Would some reader inform me if—

(1) I can use a pair of telephones that are purchased in Germany between my own and my father's house?

(2) If I can supply to other parties for use in England telephonic apparatus made in Germany?

I find that I can obtain what I want from Germany better and cheaper than I can in England; and our telephone companies, instead of crediting the Government with the stopping of the use of their apparatus, should rather credit their own short-sighted action in asking an exorbitant price for their instruments.—Yours, &c., A. F.

BALL'S UNIPOLAR DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Among other interesting notes from your special correspondent at the Philadelphia Exhibition (published in the last number of *The Electrician*) is a description of the results obtained with five horse-power from a machine of the above type. The statement that 17 arc lights are actually obtained reads well; but then, of course, arc lights differ as to power. The fact that we usually get five lights with as many horse-power does not prove that we cannot get 17 with the same source; only what is the definition of an arc light as to photometric power?

If your correspondent would kindly furnish us with results in volt amperes, I am sure it would interest many of your readers who, like myself, are quite unable to visit the Exhibition and see for themselves.—Yours, &c.,

H. A. KENT.

154, Culford-road, N., Oct. 11th, 1884.

PATENT LAW.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Having in the practice of my profession observed that exhibitors of unpatented inventions at international and industrial exhibitions are not generally aware that their position is affected by certain provisions of the Patents Designs and Trade Marks Act, 1883, I beg to point out through the medium of your paper that the six months' protection of unpatented inventions so exhibited is no longer accorded unconditionally, such protection being now obtainable only by compliance with the requirements stated in Section 39 of the above mentioned Act and Rule 17 of the Patents Rules.

Information as to the mode of procedure may be obtained from the proper official sources, or I will supply information without charge on application.—Yours, &c.,

W. T. WHITEMAN,
Fellow of the Institute of Patent Agents.

7, Staple-inn, W.C., October 15, 1884.

THE ELECTRIC LIGHTING ACT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: A case arises under the Electric Lighting Act which I should like discussed in yours if you can find space.

The Local Authority of A. invited tenders for the lighting of part of their district as required under the Public Health Act. Tenders are sent in for lighting by gas, oil, and electric light, the latter of which is successful, and the tender is accepted subject to the approval of the Local Government Board. On application to the Local Government Board for a loan to cover erection of lighting system they state that A. must first obtain a license or provisional order from the Board

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of Trade. A. has been advised that as they are their own Local Authority and only want to light the streets they are not required to have a license or provisional order. It appears, however, that although they may not purchase the plant and do their own work, yet they may contract for the lighting and pay out of the rates an annual charge for same, the plant remaining the property of the contractor. Now, if the Local Authority are willing that the contractor carry out the work and give him permission to erect the necessary plant throughout their district, must the contractor before doing so obtain a license?

From a note in yours of last week it appears that the Local Authority can give permission for the erection of plant, and this without either a license or provisional order. If so, how is it that they cannot light their own district themselves unless they have either license or order? It seems there is a want of consistency somewhere.—Yours, &c., OHM.

Kent-road, Glasgow, 14th Oct., 1884.

SIMS'S MECHANICAL TELEPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On page 445 of your issue of September 27, you mention Mr. John F. Sims's invention of a mechanical telephone. Should you know the number and date of this patent, would you oblige by favouring me with it?—Yours, &c.,

H. F. LEWIS.

Bristol, October 6, 1884.

[We have searched the patent registers for this and last year without finding a record of the patent. If the invention is patented, perhaps Mr. Sims or one of our readers will kindly supply the information.—ED. *E.*]

ELECTRICITY AT THE ANTWERP EXHIBITION, 1885.

The classification adopted for the forthcoming Antwerp Exhibition, the buildings of which are making rapid progress, comprises five sections, of which the fourth is devoted to electricity, its applications, and the necessary motors for driving the machines that generate current. This section is subdivided into six groups, and these groups again into nineteen classes, as given below. An English edition of the classification is published, but it requires revision, or those unacquainted with the French language might be at sea; for we do not generally use the term "pile" for battery, "bobbins of induction" for induction coils, nor "drums of resistance" for resistance coils.

GROUP X.—*General Mechanism.*

Class 84.—Boilers, steam engines, gas engines, hydraulic motors.

GROUP XI.—*Production of Electric Current.*

Class 85.—Hydro-electric, thermo-electric, and secondary batteries.

Class 86.—Magneto-electric and Dynamo-electric Machines and Induction Coils.

GROUP XII.—*Electric Conductors.*

Class 87.—Cables, Wires, and Accessories.

Class 88.—Lightning Conductors.

GROUP XIII.—*The Study and Tuition of Electrical Science, and its Scientific Application.*

Class 89.—Instruments used in experiments and demonstrations, *e.g.* electrical machines depending on friction or induction, condensers, electrophores, apparatus for electro-dynamic or electro-magnetic experiments, apparatus for the study of induced currents, &c.

Class 90.—Measuring Instruments: Mariners' compasses, rheometers, galvanometers, electro-dynamometers, standards of capacity and of resistance, resistance coils, rheostats, electrometers, &c.

Class 91.—Electricity Applied to Astronomy, Geodesy, and Meteorology.

Class 92.—Electricity Applied to Mechanics, Ballistics, Physics, and Chemistry.

Class 93.—Electricity Applied to the Biological Sciences; Medical Electricity.

Class 94.—History and Tuition of Electrical Science; Books, Drawings and Models; Retrospective Collections of Apparatus.

GROUP XIV.—*Transmission of Signals and Speech by Electricity.*

Class 95.—Telegraphs.

Class 96.—Telephones, Microphones, and Photophones.

Class 97.—Electricity Applied to Railways.

Class 98.—Electrical Signals for Various Purposes; Indicators of Levels, Pressure, Temperature, &c. House Telegraphs; Electric Clocks.

GROUP XV.—*Electric Current applied to Industry; Various Applications.*

Class 99.—Electric lights; photometers.

Class 100.—Electric motors; transmission of power.

Class 101.—Eletrotyping.

Class 102.—Miscellaneous applications.

The catalogue will be printed in both French and Flemish (which is almost the same as Dutch). Exhibitors have the right, for every group in which they are entered, to four lines of description free, and may pay for more space at a uniformly progressive rate, viz., 5f. (4s.) for the first extra line, 2f. for the second, and so on. We reproduce in its native quaintness some excellent practical advice given by the management:—

"The success of an exhibition depends in a great measure on the complete installation of the products at the time of its opening. Experience has proved that the delay which the installation has suffered on many occasions was principally due to the exhibitors, who either sent in tardily their demand for admission or neglected the timely forwarding of their products. We beg, therefore, to invite exhibitors to comply strictly with the periods fixed in the regulations."

THE THEORY OF THE DYNAMO-ELECTRIC MACHINE.*

BY PROFESSOR ROWLAND.

I have prepared here a skeleton of the theory of the dynamo machines. I don't claim for it perfection. I only claim to give a few points in the theory of the dynamo machine which may be of interest and possibly of value to those who are constructing these machines. Mr. Fitzgerald was to second me in this discussion and give some important points on the subject, and the discussion will be more or less imperfect unless he arrives.

The principal losses of the machine are put down under these heads:—

1st. Mechanical friction.
2nd. Foucault currents in the armature.
3rd. Energy arrested in magnetising the magnets.
4th. Self-induction of the currents.

These are the number of losses which I, at least, intend to discuss.

Of course the efficiency of the machines would then be equal to the whole work of the machine minus the different losses divided by w, namely $E = \frac{w - l_1 - l_2}{w}$.

Thus when these losses are obtained the efficiency of the machine is known.

The mechanical friction I shall not discuss.

With respect to the loss from Foucault currents in the armature, by dividing up the armature in the proper way we

* A paper read at the Congress of Electricians at Philadelphia.

can get rid of most of these Foucault currents. It is a method very often effected in the Siemens armature by dividing up the armature into discs. The greater portion of the currents are got rid of in that way.

I have purposely omitted the loss due to the change of magnetism of the armature. As the armature revolves in one of these machines the iron changes in magnetism. It has been recently experimented upon and been found that although there is some small heating effect, yet it is very small indeed. I drew attention to this fact several years ago, and experiments have been made upon this subject by makers of the dynamo machines, and Edison, for instance, has evolved a dynamo made up in this manner so that the Foucault currents do not exist, so that practically this loss amounts to nothing. I think that that question has been discussed enough, and I shall therefore take up the third loss, which is in the current, or rather in the energy, used in sustaining the magnet.

If the magnet were of steel there would of course be no loss due to this third cause, and the only reason for not using a steel magnet is that they cannot get sufficient field; the field is moderately weak. I cannot give you the ratio, but I suppose it is at least one-third of that due to an electro-magnet. Perhaps this point may be brought up in the discussion, and somebody can give us the results. But so far as I know now the field from a permanent magnet is generally less than one-third of that from a good electro-magnet. It could not be made equal to it by any possible means. Therefore, in most dynamo machines that are used on a large scale the magnet is produced by the current.

It is a question what the form of a magnet and the position of these coils should be in order to get the greatest field with the least expenditure of energy. I have one or two

FIG. 1.

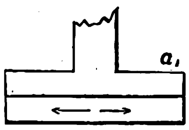


FIG. 2.

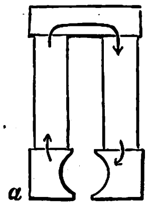


FIG. 3.

propositions to make on this subject which I think are, I will not say of vital importance to makers of machines, but of some interest.

The first proposition I have to make is that a round magnet is better than one of an elongated cross section. Those who have used the old Siemens machine will recollect that the magnets there were formed on a system of bars around which the wire was placed. If the coils are long (I do not know that it is necessary to assume that they are long if they are long enough for the purpose, and the coils are generally long enough—the theory assumes an infinite length of wire) the magnetic force at any time acting on a round iron core is exactly the same as on an elongated core; but the area of a circular section is much greater than that of an elongated section for the same circumference, and therefore the same amount of wire which would be used to go around the elongated magnet could be extended further on a circular section, and would obtain very much more work. Some people say that the principal object of making an elongated magnet is that it may include the whole length of the armature. Suppose we were constructing a dynamo machine with a very elongated magnet, we have to elongate it here (Fig. 1) and make a pole-piece in which the armature might revolve. Most makers who adopt this form think that it is better to elongate this (A, Fig. 2) out in these directions (arrows, Fig. 2). But we have seen that the round form is more efficient in general than the elongated form, and the only question is whether it will be more efficient in this particular case. I shall proceed on this theory upon the known fact that you can consider lines of force as if they were conducted by the iron and the air outside. The conductivity of the iron for the lines of force is very great—much greater than that of air. I experimented on it many years ago, and my idea is that the greatest value of the conductivity was something like five thousand times that of air. It depends upon the magnetic force, and of course it is a variable quantity.

I think it varies from several hundred up to five thousand times that of air. The conductivity is very great, especially of wrought iron; for cast iron it is probably less.

Therefore the lines of force will be conducted from any point over a circular cross section very nearly as easily as they are over an elongated cross section, and the saving in the wire will be considerable.

I have another proposition to make with respect to the magnet, and that is that one circuit of the lines of force is better than a number. Some makers might connect the pole pieces of the armature to a number of electro-magnets, and even if they were round there is loss from having a number. For this reason, that the same amount of wire produces the same magnetic force in each of these coil pieces provided there is the same number of wires per unit of length; and that same amount of wire might be made to go nine times around the iron instead of three times. Therefore you would get inside your magnet three times as much iron as you would do, and yet have the same magnetising force going on the magnet. The proposition is that one circuit is better than two, and that

FIG. 4.

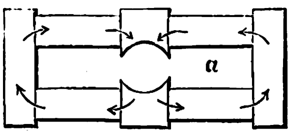
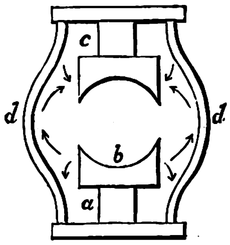


FIG. 6.



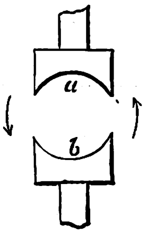


FIG. 5.

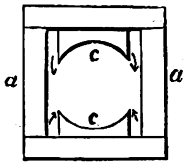


FIG. 7.

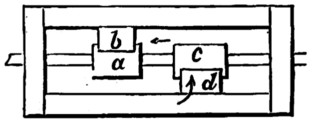


FIG. 8.

not only applies to this form of magnet (Fig. 3), but it also applies to the form where we have the armature revolving between two magnets like this (Fig. 4). Because if we should turn this section around (*a*, Fig. 4), and bring the two together, and we would have two sections. The circuit of the lines of force is around in this direction and in this (arrows, Fig. 4). So that there are two circuits of the lines of force instead of one. The working energy expended with a given amount of work will be less with this form (Fig. 3) than in the form where you have two circuits like that (Fig. 4); that is of very great value to makers of machines.

I had a number of drawings made simply of magnets in the Electrical Exhibition, and I find very great difference in this respect. There is more difference in this respect where Siemens armatures are used than in any other kind of armatures. In discussing these drawings I do not give any names nor say whether any one machine is better or worse than another; but I merely discuss the aspects of the case, and illustrate by some machines which are found in the Electrical Exhibition.

First, I will discuss in general the forms of the magnet, and I wish to say something in respect to the form of the poles that enclose the armature. Of course these forms belong both to the Gramme ring and the Siemens armature, and you may consider them both one if you wish. This magnet (Fig. 2) belongs to both of these forms and almost any form. I may mention once more that of course that theorem with regard to the number of magnets applies to a number of those old machines where there was a very large number of little magnets revolving around other little magnets. More work is used in sustaining the magnets in that form of machine than in the more modern form, where we have only a few circuits.

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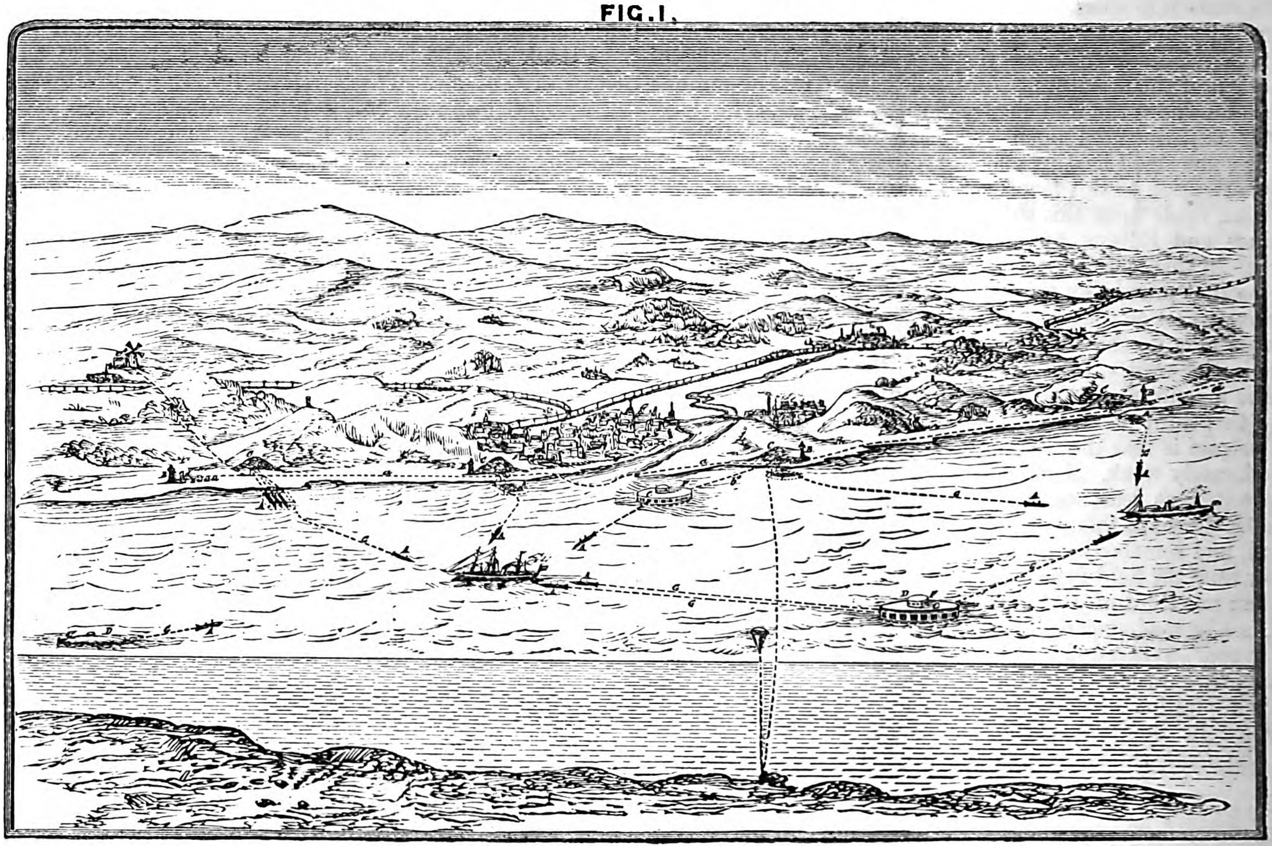
An Electrical System for Coast Defence. General Plan.

FIG. I.



We will now proceed with respect to the field in this (Fig. 5).

The lines of force proceed down the magnet and are supposed to go across here (*a* to *b*, Fig. 5). Wires are wound around the armature and revolve around across the lines of force, and so produce a current. It is evident that any lines which escape across this part (arrows, Fig. 5) are lost. If there was any leakage of the wire around the magnet, that would be lost. In case the wires touch there would not be much loss, but if there was a leakage in the wire the current, instead of going around the magnet, would go off somewhere else, and we should consider the machine defective because there was a loss of the current. If these lines of force, instead of going across there (*a* to *b*), go across here (arrows), as they naturally would do, all those lines of force are lost, and we would have to add so much more current in order to make up for this outside loss. I have an illustration of this from the drawing which I will give you (Fig. 6).

(TO BE CONTINUED.)

AN ELECTRICAL SYSTEM FOR COAST DEFENCE.

The Williams system of electrical torpedoes and coast and harbour defence, which we illustrate this week, will be tolerably clear to our technical readers from an examination of the illustrations given.

The torpedo is a decided advance upon anything which has hitherto been proposed in the class of movable and controllable torpedoes, which are by far the most effective kind of submarine engines of destruction. Hitherto the weak points of locomotive torpedoes, as exemplified in the "Whitehead" and the "fish" torpedoes, have been that when once launched they pass beyond control, and in the event of meeting adverse currents, or in the case of a change of position in the object attacked, are likely to miss their mark, and can rarely be recovered. In the torpedo of Colonel Lay, which is controlled through an electrical cable, the means employed for producing motive power constituted a hindrance to its being extensively adopted, and imposed limits to the attainment of a great degree of speed. The motor in this case was an engine constructed like a steam engine (and of about equal weight per horse-power with steam engines), and worked by means of compressed carbonic acid, the manufacture and preparation of which are chemical operations necessarily unsuited for being carried on on board ship or without special precautions on shore. In the Williams torpedo electric motors are used, the employment of which obviates all those difficulties in the working of the torpedoes, and the use of electricity as the source of motion and of control gives with suitable arrangements the means of constructing and operating an extended system of operation, as reserve stations may be distributed and worked with the smallest practicable outlay.

As to the propelling power of the torpedoes, this is provided by accumulators specially designed with large active surface and storage capacity, but with minimum weight, to rapidly discharge the power required to propel the torpedo at a speed of twenty-five miles an hour or more.

A device between the accumulators and the motor regulates the necessary supply of electric energy to the motor, which consists of a series of discs on the shaft, both the magnets and the armatures having a disc form, this giving a maximum of power with minimum of weight. The position of the rudder is controlled by devices operated electrically through a paying-out cable, through which the current is passed and regulated by circuit closers and variable resistances upon the switch-board at the base of operations.

The current regulator (worked automatically or by hand) placed in the discharging circuit gives approximate uniformity in the operation of the mechanism throughout the entire run of the torpedo, except when such automatic working is changed by the operator at the switch-board—when, for instance, he wishes to alter the speed of the torpedo.

The mechanism for working the rudder consists of solenoids, having their armatures connected with a lever on the rudder head, or of an electric motor working worm gearing combined with the rudder head, springs or counterbalance weights being used to return the rudder to midship or normal position when no current is passed through the electric mechanism.

Guide rods are also raised and lowered through the medium of a current passed through the paying out cable, operating solenoids, or other suitable devices. These rods carry hooded incandescent lamps, which are thrown into circuit either automatically by the

raising of the rods, or by hand at the will of the manipulator at the switch-board.

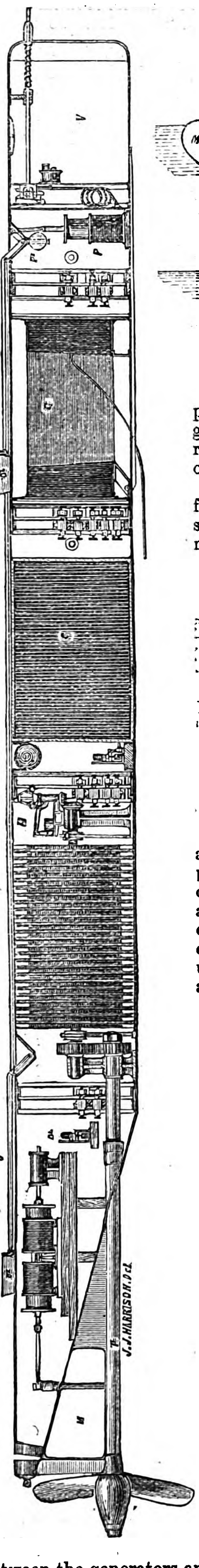
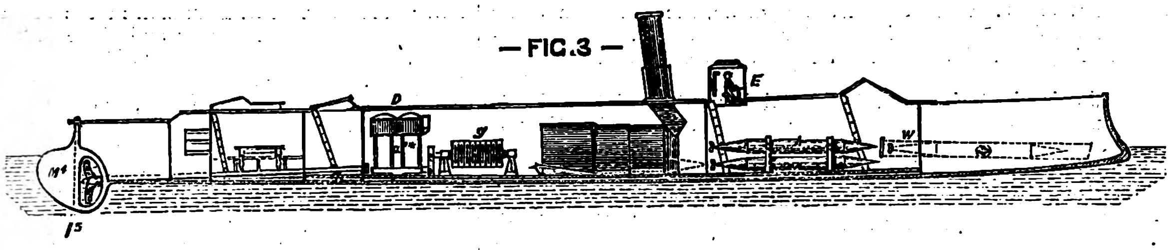
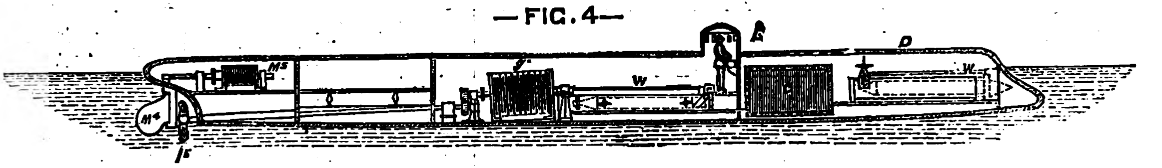


FIG. 2

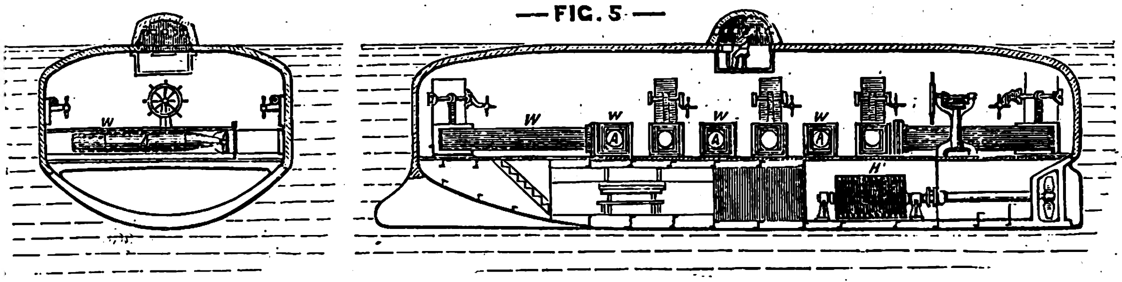

— FIG. 3 —


— FIG. 4 —

The position and direction of the torpedo are shown to the operator by the guide rods, and he manipulates the currents for controlling the propelling and other mechanism accordingly.

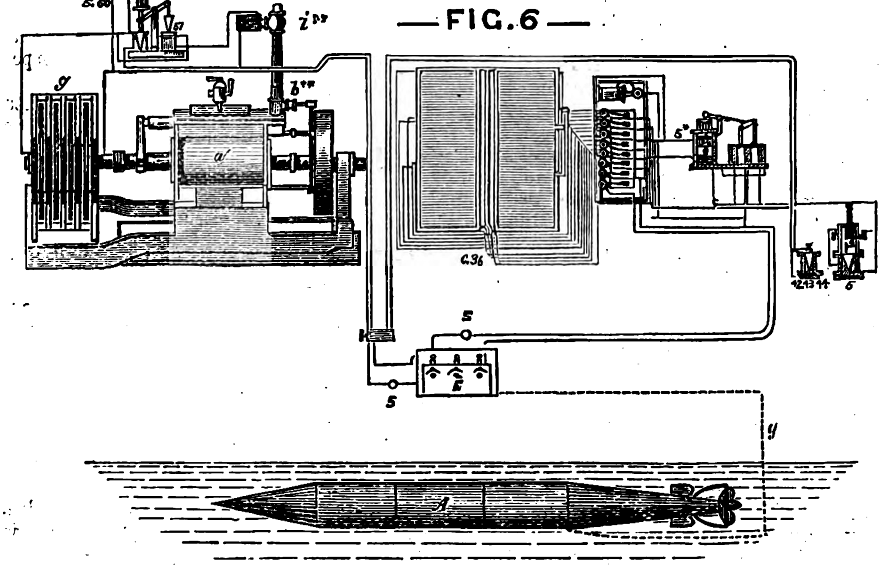
The general system, as will be seen from the drawing (Fig. 1), provides for a supply of electricity stored up in accumulators stationed at fixed points along a line of coast to be defended, which supply may be developed from wind, water, or coal power, whichever is cheapest in any given district, and conveyed by means of suitable cables of light section. In carrying out this system of distribution the use of automatic pressure regulators, variable resistances, and cut-offs, interposed between the generators and accumulators and between the accumulators and the appliances in the working circuits, secures the operation of all the various parts of the system without conflict, and of the appliances in the discharging or working circuits independent of the condition of the developing or reserve source when required.

This enables the generating or producing plant to be used to its full capacity, and the main cables or conductors to be kept constantly employed for the transmission of the energy to the distant points where it is held in reserve, and as the E.M.F. of the current in such main circuits may be high, the cables used may be of lighter section than is practicable with any other method of working.


— FIG. 5 —

The accumulators are safeguarded by having means to disconnect them automatically or by hand from the charging circuit when they are fully charged, and devices are provided for preventing the backward flow of the current towards the source.

Torpedo launches (Figs. 3 and 4), worked by electricity as well as the torpedoes themselves (Fig. 2), can be constantly kept charged and in readiness for work at the fixed points, and it is easy to lead branch cables to buoys moored off the shore, so as to provide floating stations where accumulators on board of vessels can be recharged.


— FIG. 6 —

A great advantage the torpedo has is that the accumulators can be kept charged by a small plant, as shown at Fig. 6, worked from the main boilers of an ordinary war ship or launch, or the torpedo motor can be driven direct from the dynamo, the operation being under control by the use of current regulators and variable resistances. Any man-of-war or steam launch can carry and work this plant.

The floating batteries (Fig. 5), (containing a store of torpedoes), which can be moored off a harbour or port, combined with the use of torpedo boats and the submerged batteries close in shore, render it practically impossible to approach for bombarding purposes.

The result of the practical application of this system will be that, at far less cost than that which the country goes to for ironclads, unarmoured cruisers, &c., it will be possible to protect our harbours, ports, coaling stations, &c., in a manner that will bid defiance to any war machinery existent.

JUSTICE TO ALL.

This is the title of an article in the *Warrnambool Independent*, which some kind correspondent has forwarded to us, and which we reprint below. There are in the article some sentences not quite accurate historically or scientifically, but we hardly think the *Independent* realised the statement that without Davy certain news would not be in its columns. Great praise, great honour, as well as justice, are due to Davy; but then many minds were investigating "electric telegraphs," and the required apparatus was soon to come. However this may be, our views as regards Davy's position as a pioneer in the work have long been known, and we should like to see his claims duly acknowledged, and a just meed of praise and honour given to him before time has taken the opportunity from us to give to him personally. The article we refer to is as follows:—

"Justice to All."

Justice is seldom done to the scientific benefactors of mankind during the currency of their own times, although in most cases the memories of those who have discovered wonders, or who have accomplished great things, is preserved after all that is mortal of them has passed into the oblivion of the grave. It appears, indeed, almost to be an accepted principle fully borne out in practice, that until a man who rises pre-eminent has himself paid the debt of nature, his fellow men neglect or refuse to satisfy the just claims he has upon their gratitude for services rendered. Why this is so it would be difficult to explain, except upon the theoretic grounds applicable to the case of the typic prophet who, we know, upon indisputable authority, has no honour in his own country. Death is a great leveller, and, amongst other things, sweeps away all jealous feeling, so that communities of men do not hesitate, after the great change, to do homage to the departed intellect or genius of a fellow being, even though while the philosopher or poet lived he were allowed to live as best he might, or to die for want of bread, if his ill fortune so decreed. It nevertheless does seem hard, when particular cases come under our notice, that this rule should always obtain, and that there should be no exceptions by which the closing years of a man who has made his mark might be gladdened with a generous recognition of his worth. Dr. Edward Davy, now eighty years of age, the man to whom the world is indebted for the electric telegraph to-day, unnoticed and unthought of, while messages flash from hemisphere to hemisphere, is ending his days quietly, unobtrusively, but still usefully, as a practising physician, in the unpretending Victorian town of Malmsbury. But for his discoveries in relation to, and his successful practical application of, one of the most wonderful powers in nature, not one item of the European, foreign, intercolonial, or city news of yesterday, which appears in our columns to-day, would be available for Warrnambool readers. Briefly these are the facts; with the addition, that no properly concerted, enthusiastic, or sufficiently comprehensive movement is afoot, here or in the old country, to do common justice to Dr. Davy. We are sure that when he is dead a monument will be raised to his memory. The work of his hands and of his head has supplied undying material for it. But why should not the fast fading moments of his ripe old age be cheered and made happy by some expression of tangible and unmistakable acknowledgment and approval by the nations of the earth? Not many people, in these selfish, busy times, care to spend the time to think about, much less to take action in such matters. Yet there are a few, and one of these is our townsman, Mr. John Flaxman. We published, a little time since, an answer sent by Mr. Murray Smith, the agent-general of Victoria, to a communication received from the gentleman named; and since then letters and articles have appeared in the Melbourne press, and action has been taken which will result, we hope, in the subject being remitted to Parliament at an early date. Parliament's business will be, not simply to vote an inconsiderable money grant, but to instruct Mr. Smith so that he, acting for and on behalf of Victorian opinion, will be enabled to place the movement upon an international footing. Mr. Flaxman, in the meantime, is indefatigable to promote the good cause; and, indeed, there is little time to spare. In regard to the history of telegraphy, as it leads up to and affects Dr. Davy's claim, we may submit a short statement of facts. It cannot, upon any known data, be claimed by anyone in particular that he invented the electric telegraph. It has progressively developed out of the contributions of numerous inventors. All these, prior to 1820, depended on the use of frictional electricity, and, including the ingenious proposals of Mr. Ronald, did not admit of being made very useful. Œrsted's discovery of electro-magnetism, in 1820, opened a different prospect. Ampère was probably the first to propose its use in this way. The first idea was to use 24 if not 48 wires, to work alphabetically. Cooke and Wheatstone, and at the same time Davy, showed how this might be done with five or six. Steinheil, of Munich, soon after showed how, by making use of the earth as a conductor, communications might be effected with one wire only. But still there was the unsolved problem—How far would the electricity go without losing so much of its energy by dissipation as to become inefficient for producing signals? *At this point* comes in Davy's invention of the renewer, or the relay, which solved the problem. Steinheil's one-wire improvement was one of the greatest approaches to practical perfection that had been made, and the relay principle was certainly not second to it. Both these are now in daily use all over the world. Founded on these was introduced Morse's excellent invention of dot and dash telegraphy. Davy's relay was first patented, and sold to the Electric Telegraph Company for £600, the agent with whom it was left in England not properly appreciating its value, so that, practically, Davy never got anything for his inestimable invention. Other earnest friends besides Mr. Flaxman are at work to do something that will bring about a recognition, while the doctor lives; but as "Audeo," writing to the *Argus*, says:—"Individual efforts must be superseded by collective efforts, and, although I agree that the subject should be national, yet if only the local friends and admirers were to combine to do honour to the nan of genius who has so long and worthily lived among us, not a little could be achieved in this colony alone, and it would be a centre around which the other parts would gravitate, and thus grow into national, nay, even international dimensions." We commend the subject to those who, like ourselves, desire to see shams put down and real merit rewarded. And if there are any who could and would assist, but that they are unaware of the merits of Dr. Davy's undoubted claim, we hope they will read Mr. J. J. Fahie's pamphlet, reprinted from *The Electrician*, entitled "Honour to Whom Honour is Due," and giving an account of Edward Davy and the telegraph from 1836 to 1839.

ELECTRIC LIGHTING FROM A SANITARY POINT OF VIEW.

At the Congress meeting of the Sanitary Institute of Great Britain, held in Dublin last week, the following paper on "Electric Lighting, considered from a Sanitary Point of View," by J. Angelo Fahie, C.E., Member of the Society of Telegraph Engineers and Electricians, was read before the Engineering Section.

Sir Robert Rawlinson, C.B., President of the Institute, presided.

It may be asked at the outset, What relation is there between Electric Lighting and Sanitary Science? The author hopes to be able to show that the question of artificial lighting, and especially electric lighting, has a most important bearing on sanitation, although hitherto it has not received very serious attention from this point of view. Recollecting that foremost amongst the objects of the Sanitary Institute of Great Britain are the discussion and consideration of all questions affecting, directly or indirectly, our general health, the question of the good or evil influence exercised by artificial light thereon is of the highest importance, and is, in every respect, worthy the consideration of this Congress. When we reflect what a considerable portion of time is spent by modern society under light other than natural light, and how much more injurious are all modes of artificial lighting in comparison with sun light, it is essential that we should consider anxiously the most desirable form of light which shall exercise the least ill effects on our bodily health and comfort.

In olden times man paid little attention to the subject of artificial illumination. Content to work during the day by the light of Nature, he spent his life after sunset in semi-darkness, or in the imperfect light emitted by the rude fire which served to warm his dwelling.

To the inhabitants of the East may be ascribed the first attempts at producing light by artificial means, which consisted in burning fluid bitumen in rude vessels of baked earth. Attempts were also made to utilise the fat of fish and animals for the purpose, and later on the primitive pine torch came into almost universal use as the only means of affording light after sunset. It need hardly be said that these early attempts served to fill with odour rather than light the dwellings it was sought to illuminate.

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Since the object of this paper is to consider the subject of electric lighting from a sanitary point of view, and since it is only with the general introduction of gas and petroleum the danger of injury to health arose, it is not necessary to dwell on the forms of lighting in vogue prior to the illuminants now so universally used. Nor is it necessary for our present purpose to enter into the consideration of the theory or nature of light; suffice it to say that light is the medium by which bodies are rendered perceptible to the sight. Every form of matter when sufficiently heated has the power of emitting rays of light, and thus becomes self-luminous. All artificial sources of light depend on the development of light during incandescence.

The conditions of life under all kinds of artificial light are less favourable to health than under daylight. During the day we have abundance of soft, pure, white light. The air we breathe is pure and unvitiated; it contains the heat only necessary for health. All nature delights in sunlight, the animal and vegetable organisms flourish under its influence; our energies are in a state of activity during the day. Under artificial light these conditions are completely altered; light which would be considered excessive at night is far inferior to ordinary daylight. The heat produced by all forms of light exceeds the temperature of the atmosphere in average daylight, and the air is vitiated to an extent proportional to the amount of light produced. How desirable, therefore, is it that we should seek, and by every effort in our power assist in, the development of that form of artificial light which approaches nearest the conditions existing under sunlight.

As will be seen hereafter, the light afforded by means of electricity is far superior to all other illuminants in the fulfilment of these conditions.

All forms of artificial light hitherto in use depend on combustion, in order to sustain which a good and plentiful supply of air is necessary.

Gas, for example, the chief constituent of which is a combination of carbon and hydrogen, will not burn without the aid of the oxygen in the atmosphere. In the process of combustion the particles of carbon contained in the gas come into contact with the oxygen of the air, and float in an incandescent state in the interior of the burning vapour, and this constitutes the flame. The presence of the carbon in a finely-divided state may be easily shown by holding some refractory substance in the flame, when the carbon will be deposited upon it in the form of soot.

TABLE—Showing the oxygen consumed, the carbonic acid produced, and the air vitiated, by the combustion of certain bodies burnt so as to give the light of 12 standard sperm candles, each candle burning at the rate of 120 grains per hour:—

Burnt to give light of 12 candles, equal to 120 grains per hour.	Cubic feet of oxygen consumed.	Cubic feet of air consumed.	Cubic feet of carbonic acid produced.	Cubic feet of air vitiated.	Heat produced in lbs. of water raised 10° F.
Cannel gas....	3·30	16·50	2·01	217·50	195·0
Common gas..	5·45	17·25	3·21	348·25	278·6
Sperm oil......	4·75	23·75	3·33	356·75	233·5
Benzole.........	4·46	22·30	3·54	376·30	232·6
Paraffin.........	6·81	34·05	4·50	484·05	361·9
Camphine......	6·65	33·25	4·77	510·25	325·1
Sperm candles	7·57	37·85	5·77	614·85	351·7
Wax............	8·41	42·05	5·90	632·25	383·1
Stearic.........	8·82	44·10	6·25	669·10	374·7
Tallow	12·00	60·00	8·73	933·00	505·4
Electric light.	none	none	none	none	13·8

Should, however, the supply of oxygen be insufficient, partial combustion only takes place, the carbon escaping in an unburnt condition in the form of a dark cloud, when the flame is said to smoke.

The brightness of the flame, therefore, depends on the supply of air necessary for perfect combustion.

To show that oxygen is absolutely necessary for combustion, here we have a tumbler placed over a taper, which burns nicely at first, but soon a change will be observed; gradually the flame diminishes, and at length goes out. This result is caused by the enclosed oxygen combining with a portion of the material forming the taper, producing a poisonous compound called carbonic acid, which suffocates the flame. Similarly, if we take an Argand burner and stop the aperture in the centre, the gas burns poorly because there is a restraint to the supply of air.

The light afforded by candles and lamps does not differ essentially from that of the ordinary gas burner. The same elements which constitute the one are present in the other—they all owe their luminosity to combustion. A petroleum lamp burns imperfectly without a chimney, but when this is put on, a strong draft is caused, supplying the air necessary for thorough combustion, and the brilliancy of the flame is thus materially exalted.

From what has been said it is obvious that in order to obtain the highest illuminating power of a flame, a plentiful—and what is more, a fresh—supply of air is essential. Thus it will be seen that wherever light is obtained by combustion, it deprives the air of oxygen, that element which has justly been termed the "ærial" food of animal life. Moreover, in the process of combustion the air is contaminated with certain poisonous compounds, such as carbonic acid, carbonic oxide, and sulphur, which, when breathed even in a limited quantity, are injurious to the human frame. Another effect of combustion is the production of vapour, formed by the oxygen of the air combining with the hydrogen, which constitutes a portion of the material consumed. The presence of this vapour will readily be detected if a decanter of cold or iced water is brought into a room where a number of lights are burning. The surface of the decanter will be speedily covered with a thick dew, caused by the vapour floating in the air being condensed by the action of the cold water within.

As we all desire to live in pure air, is it not strange that we should be content to use a light which not only robs the atmosphere of oxygen, thus destroying its life-supporting virtue, but actually loads it with noxious vapours, the products of combustion?

Considering the comparative merits of the various artificial lights now in use, the above table from Dr. Tidy's "Handbook of Modern Chemistry" will afford some idea of the heat-producing and air-vitiating effects of the different bodies enumerated. To this table Mr. R. H. Hammond has added the effects produced by a 12-candle incandescent electric lamp.

From this table it follows that an ordinary gas burner consuming 5 cubic feet per hour absorbs nearly 5¼ cubic feet of oxygen per hour, or, in other words, it deprives 17 cubic feet of air of its oxygen in an hour. But, as has been already pointed out, gas not only deprives the air of its health-giving oxygen, but it contaminates it with poisonous compounds which are more or less—according to the extent to which they exist—injurious to animal life. Dr. Tidy considers that the contamination of the atmosphere in a crowded theatre at the end of the performance may be regarded as distressing, and many of us experience a disinclination to go to the theatre because of the inconvenience suffered from the heat and vitiation of the air caused by the gas, producing headache and oftentimes giddiness. The effects of heat and vapour from combustion will be readily detected in a wareroom or shop, the lower portion of which may be only at a temperature of 60° to 70°; in consequence of the hot air ascending, the temperature near the ceiling will probably be from 130° to 140°. When, therefore, goods, books, &c., are placed in such high localities it cannot be wondered at that they become injured or destroyed.

Turning to the table above quoted, we find that electric lighting by incandescence produces absolutely none of the evil effects just enumerated. There is no oxygen consumed, no carbonic acid or other compounds given off, and, consequently, there is no vitiation whatever of the atmosphere; and, as to the heat-producing effects, the table shows that the air of a room lighted by gas is twenty times more heated than if lighted by incandescent electric lamps. From this it will be readily seen how conducive to health and bodily comfort are the conditions fulfilled by electric light in contrast with all other illuminants. And not only is the health and bodily comfort affected by the influence of artificial light, but the temperament also; and it is very remarkable to notice the difference in the effect produced by gaslight and electric light on the spirits of those obliged to work long hours at night. A brilliant light, we all know, exercises a cheerful influence on the animal spirits, and electric lighting affords unusual facilities for acquiring a higher degree of illumination without the accompanying heating and air-vitiating evils inseparable from gas and petroleum.

It has been said, as an argument against the use of electric light, that it is injurious to the eyesight, and, therefore, cannot be considered as conducive to health. This argument is more imaginary than real, and has no foundation in fact. As compared with other lights, electric light is less injurious, when used under proper conditions. True, an unsteady or flickering light has an ill effect on the sight, and electric lighting on the *arc* system is open to this objection, a defect which, however, will doubtless be remedied in time. But the *incandescent* system leaves nothing to be desired; the light is pure, soft, and white, and is absolutely steady in its action.

It is this system which concerns us at present, since it is the most suitable for indoor purposes, and consequently bears directly on the question of health.

The flame of a candle, or a gas flame, is not absolutely steady, although considerable improvements have been made in gas lighting, during recent years, by the introduction of better burners and more suitable globes; but in some cases—for instance, in factories—globes cannot be conveniently used, and the flame is ever subject to drafts, causing a disagreeable wavering or flickering in the light. It is impossible that the light of the incandescent electric lamp can be affected in this way.

The glare of the electric light is also commented on as being objectionable; but this is only applicable to the arc light, and even this form readily admits of being shielded in ground globes; and as it is only suitable for outdoor use and for large buildings, it is not necessary here to say much about it. It might, however, be said *en passant* that we have no right to stare at the electric arc any more than we have to stare at the sun, which makes our eyes weak, and otherwise inconveniences us. A strange story is told in the newspapers a few days ago, of a boy, aged about 14 years, who, for a wager, stared at the sun for some time and died the same night in great agony. Professor Pickering, a German *savant*, recently made an investigation into the cause of weak sight amongst the students of his university, and traced it to the heat given off by their reading lamps, which dried up the humours of the eye. Seeing that the electric light gives off but a trifling degree of heat it is, therefore, far preferable in this respect, and far less injurious to the sight than gas, oil, or candle light.

Many institutions throughout the country are now lighted by electricity, and in every single instance with the most beneficial results to the health and comfort of the people who work by its aid.

It would be impossible in a small space to describe the lighting arrangements in these institutions, but the author may be permitted to refer to one installation which has been working under his charge for the past nine months, and which will serve as an illustration for many others. The installation referred to is that of the offices of the *Irish Times*. The composing room here forms one large apartment, measuring some 60ft. by 40ft. by 70ft. in height. Before the introduction of the electric light, this

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apartment was lighted by 100 gas jets, and, remembering that one gas jet consumes as much oxygen as five individuals, and adding to this the effects resulting from the breathing of the compositors, together with the long hours of night during which the work is carried on, we can readily conceive how extremely unwholesome and unhealthy must have been the air of this apartment. Indeed, as a matter of fact, the *employés* frequently suffered from ill health and discomfort, which they usually attributed to the vitiated state of the atmosphere, and it was not unusual to have several out on sick leave at one time. This was especially noticeable in summer. The temperature of the apartment frequently ran as high as 85° in winter, and 95° in summer. The discomfort occasioned sometimes in summer was very serious indeed, oftentimes rendering it impossible for some of the men to carry on their business for the usual number of working hours.

Since the introduction of the electric light the condition of things is entirely changed. The atmosphere is pure and healthy, the thermometer rarely marks higher than 70° during the night, the light is bright and perfectly steady in its action, the health of the *employés* is good, and their spirits cheerful and buoyant, many of them being able to work for considerably longer hours now than formerly, and the sick list has all but disappeared.

This proves that not only from a sanitary but also from a *commercial* point of view is the introduction of the electric light beneficial.

It may be argued that a proper system of ventilation would render the use of gas harmless; but the question of ventilation, although apparently so simple, is difficult to deal with. Sometimes arrangements adopted to ensure a good supply of fresh air may be admirable in calm or warm weather, and just the opposite in cold or boisterous weather. Again, a means of ventilation may work well for a period, and unexpectedly, perhaps, owing to a change in the wind, instead of the noxious products of combustion passing off, the wind rushes in with occasional gusts, causing the flame to become agitated and smoky, and the air is vitiated to even a greater extent than otherwise. With the electric light the difficulty of ventilation is reduced to a minimum.

Amongst other advantages of the electric light which, although not strictly relating to its sanitary aspect, have nevertheless an indirect effect on health, may be mentioned the following:—Plants grow in rooms lighted by it, and cut flowers exhibit their true colours, and do not quickly wither; paintings show their natural tints and colours to better advantage. Its influence on the health of children is incalculable. An electrically lighted nursery, even if the light remains on all night long, is free from the noxious vapours produced by candles or gas. The electric light also lends itself to artistic treatment in the most admirable way.

In the adoption of the electric light, therefore, we fulfil the following important considerations:—We do not deprive the air of oxygen, so necessary for our health and comfort; we do not adulterate the air with pernicious compounds of any kind; we avoid the accumulation of vapour; only a small degree of heat is produced; and we facilitate the means of ventilation.

In fact, by means of electricity, we have at last obtained an artificial light which is nearly all that could be desired; and, regarded from a sanitary point of view alone, its development and introduction should command our warmest sympathy and earnest support.

It may be expected that some reference might be made here concerning the expense of the electric light, but since the subject has been dealt with chiefly from a sanitary point of view, and as the question of first cost and maintenance involves considerations which could scarcely be fairly treated in a paper of this kind, the author may be excused for not entering into details or comparisons of cost.

So long as electric lighting is carried on in isolated installations, it will be found difficult, no doubt, to compete with its older rival, although there are cases where the cost of such installations compares favourably with gas. The expense of maintenance by isolated lighting is governed entirely by local considerations. Where the light is required only to a limited extent—say 100 incandescent lamps burning for less than 1,000 hours per annum—the cost will probably exceed that of gas; but where the number of lamps reaches 200 and the number of working hours amounts to about 2,000 per year, then electricity will undoubtedly beat gas. It is, however, unfair to compare the expense of lighting by isolated installations with that of lighting by means of a well-established and elaborate system, whose existence is founded on the experience of half a century. However, in considering the question of expense, the superior advantages which we have endeavoured to point out, inherent in the electric system, should entitle it to a higher price than all other systems of artificial illumination.

The time will come, however, when the electric current will be supplied on a large and comprehensive scale, and when its merits will be fully appreciated by all; then the question of cost will no longer form an insuperable barrier to its universal adoption.

A discussion followed, and

Sir ROBERT RAWLINSON, in summing up, spoke as to the purity, brilliancy, and wholesomeness of the atmosphere wherever the electric light was used. He thought that its advantages over all other illuminants would sooner or later recommend its universal adoption. But there were still difficulties to be got over in order to make it a perfectly safe and certain means of illumination. He referred to the fact of its having gone out at the Health Exhibition, where it was worked under the most favourable conditions, and also alluded to the unfortunate accident which occurred the other day, resulting in the death of one of the attendants on a dynamo used for arc lighting.

Mr. FAHIE, in reply, said that no doubt there were still some difficulties which impeded the successful and economical application of the electric light, but it should be remembered that difficulties had always to be overcome in the introduction of every new industry, and those attending electric lighting were being removed from time to time, as electricians gained experience by actual practical work. As to the accident which occurred at the Health Exhibition, it simply arose from the attendant incautiously placing both his hands at one time on or in connection with the opposite brushes of the dynamo, thus receiving through his body the current which was being generated to feed some 23 arc lamps. It appears that the unhappy man had been cautioned against placing both hands on the machine, and the accident was wholly due to negligence.

During the reading of the paper Mr. Fahie exhibited a specimen of the spectacles or goggles recently devised by Dr. W. H. Stone for the use of electrical engineers and others connected with electric lighting. These goggles have blue glasses in the front, and are provided with side glasses tinted red. When looking at the incandescent light the blue glasses are used and the red rays neutralised, while for the purpose of examining the arc light the red side glasses are turned down and both are used, by which means any danger to the eye arising from excess of blue rays is obviated.

COMPANIES' MEETINGS & REPORTS.

The Eastern Extension, Australasia, and China Telegraph Company (Limited).

The twenty-second ordinary general meeting of this Company was held on Wednesday, the 15th inst., at the City Terminus Hotel, Cannon-street, under the presidency of John Pender, Esq., M.P.

The SECRETARY (Mr. F. E. Hesse) read the notice convening the meeting and the minutes of the last meeting, which were confirmed and signed by the Chairman. The report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, I have no doubt that in reading the report you have found it on the whole very satisfactory, and I have great pleasure in congratulating the shareholders on our being able to put such a satisfactory report before you. As usual, the report not having been read, I shall go over some of the figures, so as to give some little explanation. The gross receipts for the half year have been £237,672, against £213,729 for the corresponding period of 1883, showing an increase of £23,943. The working expenses for the same period amounted to £66,658, against £62,778 for the corresponding period of 1883, showing an increase of £3,880. This is practically made up by an increased expenditure of £910 on account of maintenance of the Company's lines, and to the additional salaries at foreign stations, amounting to £2,680, necessitated by the opening of new stations. The net revenue for the half year was £127,415, against £107,356 for the corresponding period of 1883, showing an increase of £20,059. Against the half year's revenue the Directors have charged £22,767 for the renewal of the teredo exposed portion of the original portion of the Java-Australian cable, by which means the whole of the work has been carried out without any charge to capital. I think you will approve of this as being a sound proceeding. In addition to this long lengths of brass-ribboned cable have been inserted in the Singapore-Saigon and Penang-Rangoon sections, where the teredo has been found troublesome; but as those renewals have been effected since the close of the half year, they will be dealt with in further detail in the current half year's report. With respect to the dividends, one interim dividend for the half year, at the rate of 5 per cent. per annum, was paid on the 15th of July, and another of a similar amount, together with a bonus of 2s. per share, was posted to the shareholders last evening, making a total payment of 3½ per cent. for the period, against 3 per cent. for the corresponding half year. The balance of £17,147 is carried forward. With respect to the 5 per cent. Australian Government Subsidy Debentures, 909 of these were drawn on the 23rd of April last in terms of the trust deed, and the necessary funds were placed at the disposal of the trustees for meeting the payment of the same. Up to the present time 654 have been lodged with the bank and paid off by the trustees, leaving 255 still outstanding. Of these only six are "registered," the balance being held "to bearer." With regard to the opening of new cables, as stated in the report, the new cables between Hong Kong and Tonquin and between Macao and Hong Kong have been successfully laid during the half year under review, and opened for traffic. It will be in the recollection of those who were present twelve months ago that I shadowed forth what was likely to take place in the negotiations we were then having with the French and Portuguese Governments, and, as just now stated, all those negotiations were successfully completed, and resulted in our establishing for the French Government a connection between Singapore, Annam, and Tonquin, for which they pay us £10,600 a year, and also a connection between Macao and Hong Kong, with a subsidy from the Portuguese Government of £500 a year. All this has been done in the twelve months, and has worked satisfactorily. Unfortunately one of the cables—that between Hong Kong and Tonquin—was interrupted, but as I have frequently said at these meetings lately we have so thoroughly mastered the mode of repairing and finding out where a fault exists, that we have now very little hesitation in dealing with it, whereas some years ago an interruption put us all into a very great flutter. The cable is now, however, repaired and at work again. Another between Saigon and Hong Kong is now interrupted, but we expect every hour to hear that it is repaired, the steamer "Agnes" being on the ground of the fault. I have men-

tioned frequently that the great object of this Company is to secure permanent and continuous telegraphic communication with the important places with which we have connected our cables. We have found that without duplicate cables interruptions are very serious; not so very serious perhaps to the Company (although the loss is very considerable, as I shall show you) as it is to the public, as a very large amount of commerce is now being carried on by means of the telegraph, and it is therefore our duty to those who support telegraphy (always having the interests of our shareholders in view), that we should make our system so thoroughly efficient that merchants may rely upon it. The principal interruptions during the half year under review were between Madras and Penang, for thirty-seven days during the south-west monsoon, and between Java and Australia for seventeen days. The traffic was transmitted by the alternative lines, and consequently there was no loss to the merchants, nor to the Company. If we had not had the duplicate lines the loss to the Company would have been £23,000 for that comparatively short number of days, so that by duplication we not only maintain our traffic but we give confidence to the merchant, who is involved in important operations at a particular time, and thus secure his confidence and increasing support. We had also an interruption on the Victoria and Tasmania cable for fifty-nine days, but not having a duplicate line, the loss, although it is only a short cable carrying comparatively speaking only local traffic, was for that short period about £1,600. It is our intention to duplicate the line, which we shall do from the cable we have taken up and replaced with brass-ribboned cable to fight the teredo. This stock cable costs us a comparatively small amount of money, and will add very little, if anything, to the capital of the Company. In that way we propose to continue the policy of duplication where now we are dependent on single cables, and thereby secure for the Company such a continuity of telegraphic communication as will best maintain our dividends, and above all serve the merchants who are depending on telegraphy. I may mention that in completing our system to China we have had, as I have frequently stated, some trouble and difficulty with the Chinese. We have had a good deal of difficulty lately through the hostilities going on between the French and the Chinese in maintaining our connection with Foochow, but I am glad to say we have been enabled to maintain the service between Sharp-Peak Station and Foochow, although under very difficult circumstances. I think that the Chinese, seeing that we are honest and in earnest, have pretty well agreed to do what we have asked them—namely, to give us a line from Foochow to connect with our cable at Sharp-Peak. In that way we have our cable worked under English supervision, which will give us all we could desire, and save us the expense of maintaining expensive Chinese offices. A good deal has been said in the newspapers, and it is a question I find even some of our shareholders take a very strong view about—about the reduction of our rates. Having been a merchant myself, and knowing something now of the value of telegraphic communication, and the expense of it to merchants, I am very anxious, whenever I see our interests can be served by a reduction in the tariffs, to give effect to it. But it is a very curious fact that the reductions we have tried have not resulted in any degree to encourage us to go on with it to any great extent. When we find that there is a response, and that it is being availed of to an extent that will recoup us for the loss we make by the reduction of the tariff, we shall only be too glad to extend the privilege. But I have learned this, that in all important transactions involving thousands of pounds—many thousands of pounds often—the question whether it is a small or large sum for telegraphy when the charge is within moderate compass does not enter so much into consideration. These operations are carried on, the telegraph must be used, and the consequence is that we get the returns. When the duplicate Australian cable was laid it was arranged that Press telegrams between England and Australia should be carried at quarter rates over the Extension Company's system, and although the privilege has been in force for five years the number of words transmitted has only increased by 11 per cent., whereas the receipts show a loss of 72 per cent. Now, that is a very conclusive argument. As a further illustration, I may mention that when the Atlantic cable companies reduced their tariff from 2s. per word to 1s. the increase in the number of words sent was only 22 per cent., whilst the loss of revenue was 37 per cent. Subsequently, when the rate was increased to 2s.—a rate which we find is about the lowest rate that can be really worked with anything like a fair return—the number of words transmitted at the lower charge only decreased 12 per cent., whilst the revenue increased 58 per cent. As an explanation of these figures, it should be mentioned that the out-payment to other administrations included in the rates of 1s. and 2s. are in some cases fixed charges. Hence the cable companies make a heavier loss at a rate of 1s. than 50 per cent. of the receipts at a 2s. rate. I mention these facts because I think it is well that the shareholders should clearly understand the question. There is a very general idea that if you only reduce the rates you will largely increase the returns. We have not found that to be the case, but I am quite prepared to say, and I believe I express the opinion of my co-Directors, that when we see good grounds for making further reductions in the rates we shall only be too glad to make them. There is another question I will take this public opportunity of referring to. I see there has been an attempt to get up an agitation in the newspapers against any alteration in what is called the coding system, and to bring this matter before the Conference which is to be held in Berlin next year. I know that these coding systems are got up at a very great expense by merchants. They have shown wonderful ability in them, and they have beaten us at all points. They have got the advantage of the fight most completely, and with a few words they can fill pages of paper; whereas we originally contemplated that with open words we should get a larger number of words. Had we got that amount of business in open words our dividends would have been very different to what they are. But the coding system has been got up at very great expense, and I may say that we have no intention whatever of proposing at the Conference any alteration in the present coding system. I wish the Press to notice this, as I think it is well that merchants should know that we are not working in antagonism to them, but that we are doing all we can to meet their wishes where those wishes can be met consistently with the best interests of the shareholders. I think I have now pretty well exhausted my remarks, and conclude by moving "That the report and accounts of the Directors now submitted be received and adopted."

The Most Hon. the Marquis of TWEEDDALE seconded the motion.

After some remarks from Mr. Newton and Mr. Griffith in reference to the reduction of tariffs, the preservation of the existing coding system, &c.,

The CHAIRMAN said: I may mention in reply to Mr. Newton that it was the Company that first suggested to the merchants a coding system, and I may also repeat what I have stated so very often, that if a coding system had not been adopted we should not have had cables enough to carry the traffic, and therefore, as you can well understand, we encouraged them, and are anxious that the merchants should do their work as cheaply as possible. I may say that they have done it so very well that they limit to a very considerable extent the dividends which we originally anticipated we should be able to pay. As I have said before, we are working hand in hand with the mercantile community, and as I have already pointed out, whenever we can reduce our rates consistently with securing our dividend we shall only be too glad to do it. There was an important conference held in Australia about a year ago, and the question of lower telegraph rates was considered at that conference, because they considered telegraphy of such great public importance. We were appealed to, and we said: "We are earning such and such a sum, which is paying such and such a dividend. You may make the rate between England and Australia what you please if you will guarantee to us the sum we now earn." That was a very fair challenge, showing that we had done everything we could to meet the colonies for political purposes and the merchants for mercantile purposes. We are prepared to repeat the offer. It is our business to preserve your interests, however, and I think we should not have had the pleasant receptions from you that we have had for the last few years if we went on reducing the tariff and the dividends at the same time. I think you must give us your confidence in so far that we will—always having a due regard to your interests—do the best we can to develop telegraphy between this and our distant stations. I think I have pretty well answered Mr. Newton's questions. As to those of Mr. Griffith, I am afraid if we carried out his views, which are generally very prudent, it would involve very considerably reduced dividends—that is, if we insured our cables as he suggests. Whatever we can insure with propriety we do, namely, our ships; and we do more, we take a certain risk on our ships. I think altogether, looking at the affairs of your Company at the present moment, I doubt if I could make any important suggestion, or if there is any suggestion by which I could place your affairs before you in a more sound or fairer light than we have done to-day. We should bear in mind the development of the traffic, and upon that development will depend the realisation of Mr. Newton's idea of an increased dividend. But we have a good deal to do, and I wish you to bear that in mind. We have some duplications still to carry out, and if we can do that out of income instead of capital I think we shall strengthen ourselves to a great extent. I shall be very glad to have an expression of opinion on the part of the shareholders on this point. Seven per cent. is a very good dividend, and if we can make that 7 per cent. doubly secure by not adding to the capital while adding to the strength of our position, I am sure you will agree that the policy of the Board is a sound one [hear, hear, and applause]. I now beg to submit the resolution.

The resolution was carried unanimously.

Mr. NEWTON: I beg to propose a vote of thanks to the Chairman for presiding over us to-day. I take this opportunity of doing so to congratulate myself on having elicited the important statement which you have just made—that you made such a splendid offer to the Australian colonies which you mentioned. I think it removes all cause of complaint on the part of the Australian colonies. I desire to include your colleagues in this vote. Although I have come into collision with you in past years, it is due from me to say that, under your management and care, telegraphy has become—taking into consideration the rate of dividend paid—the soundest and best investment in the market [hear, hear]. I don't object to your limiting the dividend to 7 per cent. when you make such substantial additions to capital account out of revenue.

Mr. GRIFFITH: I second the motion. I think we are greatly indebted to the Directors for the present position of our Company, for the large dividend we are receiving, and for the substantial state of the concern. In answering the questions which I put, there was one you omitted in connection with the auditors' certificate. I have no doubt that all our securities are perfectly in order and perfectly safe, but the auditors' signature does not include the investments and the securities. If you tell us that it was intended to do so, I shall be very much obliged to you.

The CHAIRMAN: You are aware that when auditors sign the balance-sheet it embodies all this. There is no further signature necessary. They have there given their signatures to the whole account. It is not necessary to certify separately every particular item. I am very much obliged to you for the way in which you have expressed your approval of the Board's policy. I may say that the little talk that we have had to-day elicits information, and I think strengthens the position of the Company before the public. I am always delighted to give an answer as far as I can to satisfy the questioner, and I hope if the relations between this side of the table and the shareholders' side continue as they are likely to do, we shall not go back, but become stronger and stronger, and make it appear before the public that telegraph property is really a good, sound, substantial investment.

The proceedings then terminated.

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The West India and Panama Telegraph Company (Limited).

Report of the Directors to be presented to the members at the fifteenth ordinary general meeting, to be held on Wednesday, the 22nd inst.:—The accounts for the six months ended 30th June, 1884, show the amount to credit of revenue to be £50,677 5s. 10d., and the expenses £28,893 17s., leaving a balance of £21,783 8s. 10d., which, with the balance of £2,519 7s. 2d. brought from last account, make a total of £24,302 16s. Of this sum the Directors have placed £10,000 to reserve, leaving an available balance of £14,302 16s., with which it is proposed to deal as follows:—Payment of 6s. per share on account of arrears of dividend on the first preference shares, £10,368 18s.; balance to current half year's account, £3,933 18s. The traffic receipts show a decrease of £3,059 9s. 4d. on those of the corresponding period of 1883, which is partly attributable to the depression in the sugar market and the interruption of the Demerara cable referred to in the last report. It must, however, be remembered that the returns for 1883 were augmented by the exceptional traffic during an interruption of the Central and South American Company's cables, which compete with the Company's system at the Isthmus of Panama. On the other hand, the revenue for this half year has benefited by the chartering of the Company's ss. "Grappler" to the International Ocean Telegraph Company for the repairing of their Havana-Key West cables. Satisfactory progress has been made towards the restoration of the original Jamaica-Porto Rico cable, the repairs of which have now been completed from San-Juan (Porto Rico) to within 30 miles of Jamaica. The "Grappler" is now at work at the Jamaica end, and it is expected that the re-establishment of this important duplicate cable will be shortly reported. This operation, which will add materially to the security of the communications with the whole of the West Indian colonies eastward of Jamaica, has, owing to the great depth of water and the nature of the sea bottom, been both tedious and costly. It is hoped that this effort of the Company to maintain and fortify the colonial connections to an extent far in excess of that contemplated by the single line system, which formed the basis of the original contract with the colonies, will be recognised by both Imperial and Colonial Governments, and by the interests associated with West Indian possessions, whether British or foreign. The appeals to the colonies for some revision of the unfortunate arrangements entered into at the formation of the Company have resulted since the last meeting in an increase of the Grenada subsidy, from £500 to £1,000 per annum, and of the St. Lucia subsidy from £500 to £800 per annum, both to commence on 1st January, 1885. These additions to the Company's resources deserve the most grateful acknowledgment to the colonies which have granted them, and give a much needed encouragement to the Company's endeavours to maintain the telegraphic system of the region. The colony of St. Vincent declines at present to augment its subsidy on the ground of the depressed condition of the sugar trade. The situation in Barbadoes and the Leeward Islands remains unchanged. The terms for which the foreign colonies Guadeloupe, Martinique, and St. Thomas granted their subsidies expire on the 31st December next, and applications have been made to them for renewals. The severe crisis through which the commerce of the West Indian colonies is now passing, causes much anxiety to the Directors, although the traffic receipts of the current half year have not as yet been impaired. Several interruptions to the cables occurred during the half year under report, which were repaired with every possible despatch.

The Telephone Company of Ireland.

Report of Directors presented at the fourth half-yearly ordinary general meeting on the 17th inst.:—

The Directors present their report and statement of accounts for the six months ending the 30th June, 1884. The number of subscribers to the exchange system of the Dublin district, and also of the renters of private lines, as compared with the corresponding period last year, and also with the 31st December, 1883, is as follows:—June 30, 1883, exchange 411, renters 127; December 31, 1883, exchange 507, renters 140; June 30, 1884, exchange 568, renters 168. As the shareholders are aware, the business of the Company has hitherto been limited, under the Post Office licence, to the Dublin district only, within a radius of five miles from the central Post Office. The Postmaster-General has, however, now agreed to grant licences without limit as to radius, and the Directors will thus be enabled to extend the operations of the Company within their territory wherever they find the business can be made remunerative. The new licence will permit the Company to open public call-offices, and also to give intercommunication between towns. The Directors anticipate that these privileges and conveniences will tend greatly to facilitate business, and be of considerable advantage to the Company. That the telephone supplies a want not met by the telegraph—namely, that of obtaining an instantaneous reply, is demonstrated by the fact that the gross rental of the Company from the Dublin district alone is now already upwards of £8,000 per annum over an area with a radius of five miles from the central Post Office, whilst the amount received by the Post Office Department from telegrams despatched from an area with a radius of twelve miles from the Post Office to addresses within the same area, as stated by the Postmaster-General in the House of Commons on the 9th June, 1884, was only £1,390 per annum. The line to Kingstown is now practically complete, and will be opened to the public so soon as the new licence from the Post Office has been perfected. The Board have to thank the Directors of the Dublin, Wicklow, and Wexford Railway Company for the liberal spirit in which they have granted the necessary way-leave for poles to carry this line along and across a portion of their railway. With a view to provide sufficient funds for the development of the business, without using the uncalled capital, and for the reasons already explained to the shareholders, the Directors have considered it advisable to place a further portion of the unallotted shares. This they have done (after first offering said shares to the shareholders) to an extent sufficient for the present purposes of the Company without the necessity of any appeal to the public. These shares were offered as six per cent. shares, which the Directors propose to exchange into five per cent. shares, at the rate of 120 five per cent. for 100 six per cent., in accordance with the terms of the issue. Subject to the approval of the shareholders, the £2,258, being 10s. per share credited as paid on the 4,516 five per cent. shares issued during the half year ending 30th June, 1884, on conversion of the six per cent shares into five per cent. shares, in accordance with the special resolution of the 7th September, 1883, has been written off to expenditure on capital account, and the Directors propose to write off in like manner such further sum as may be credited in connection with the exchange of any six per cent. into five per cent. shares of the authorised issue of £50,000. Since the date of the last half-yearly meeting still further progress has been made in the conversion of the 25,000 old six per cent. shares. At date of last report 3,720 shares remained unconverted. This number had been reduced on 30th June last to 2,405, and the Directors propose, subject to the approval of the shareholders, to redeem and extinguish the small balance of these shares now remaining, upon the following terms:—To exchange the six per cent. shares, 10s. paid, for five per cent. shares fully paid, at the rate of five six per cent. shares, 10s. paid, for three five per cent. shares fully paid, or upon such other terms as may be agreed upon, or as in the opinion of the Directors may be most beneficial in the interests of the Company. The amount standing to the credit of profit and loss, including the balance of £259 15s. 4d. brought forward from last account, amounts to £1,362 10s. 7d. This admits of payment to the preference shareholders of the full dividend, amounting to £388 0s. 4d. upon the preference shares; also of a dividend at the rate of 1 per cent. per annum upon the ordinary shares, amounting to £875, as against nil for the corresponding half year ended 30th June, 1883, and of ½ per cent. for the last half year ended 31st December, 1883, leaving a balance of £99 10s. 3d. to be carried forward to the credit of the current half year.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Oct. 15.		Business Done Week Ending Oct. 15. Highest.	Lowest.
Anglo-American	31⅛,	32⅛	34⅛	32¼
Do. Preferred	55½,	56½	57½	55½
Do. Deferred	6¾,	7¼	7¼	7⅛
Brazilian Submarine	11⅛,	11⅝	11⅝	11¼
Cuba	11,	11½	11	—
Do. Preference	17,	18	—	—
Direct Spanish	3½,	4	—	—
Do. Preference	14¾,	15¼	15⅝	—
Direct United States Cable	9⅞,	10⅛	10⅛	10
Eastern Telegraph	11⅝,	11⅝	11¾	11⅝
Do. 6 per Cent. Preference	13½,	13¾	13¾	13⅝
Do. 5 per Cent. Debentures, 1899	104,	107	—	—
Eastern Extension	11⅞,	12⅛	12⅜	12 3-16
German Union	9¾,	10⅛	—	—
Globe Telegraph and Trust	6⅞,	7⅛	7¼	7 1-16
Do. Preference	12⅜,	12⅝	12 13-16	12½
Great Northern	18½,	13¾	13 1-16	—
Indo-European	32,	33	—	—
Reuter's	7¾,	8¼	—	—
Submarine	175,	185	—	—
West India and Panama	⅞,	1⅛	1	—
Do. 1st Preference	7¾,	8¼	8	—
Western Brazilian	6⅝,	6¾	6¾	6⅝
Western Union 7 per Cent. 1st Mortgage	123,	125	—	—
Do. 6 per Cent. Sterling Bonds	100,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	5-16,	7-16	⅜	—
Oriental	⅛,	⅜	—	—
United Telephone	13½,	13¾	13¾	13 3-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1½,	1¾	1½	1
Do. (fully paid)	2¾,	3¼	—	—
Hammond Light (£3 15s. paid)	⅛,	⅜	⅜	—
Swan	—	—	—	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	34,	35	34¾	—
India Rubber, Gutta Percha, and Telegraph Works	22½,	23½	23	22½

TRAFFIC RECEIPTS FOR SEPTEMBER, 1884.

Companies.	Sept., 1884.	Sept., 1883.	Increase.	Decrease.
Cuba Submarine	2,150	2,515	—	365
Eastern Extension	41,590	39,576	2,014	—
Eastern Telegraph	50,913	42,778	8,135	—
Great Northern	26,000	—	—	—
Direct Spanish Telegraph	1,619	1,710	—	91
West Coast of America	8,465	—	—	—

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NOTES.

CHINA AND JAPAN.—The cable between Haiphong and Hong Kong is repaired.

ELECTRIC LIGHT AT BRUNN.—In addition to the installation at the theatre, four cloth factories are now lighted by the Edison system, requiring about 700 A lamps.

THE TELEPHONE AT PHILADELPHIA.—The laying of an underground electric cable for telephone purposes was begun by the Philadelphia authorities on the 2nd of October.

TELEGRAPH CLERKS' GRIEVANCES.—It is stated that Professor Fawcett, M.P., Postmaster-General, has refused the country telegraphists' application to be paid for Sunday work.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 5th October are £1,679, as compared with £2,369 in the corresponding period of 1883.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 17th October, were £2,301, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE CHINESE TORPEDO SERVICE.—The Berlin correspondent of the *Morning Post* states that the French operations at Tamsui were in a great measure frustrated by the torpedoes which were laid by a European, Mr. Betts, of the Silvertown Company, and head of the Torpedo College at Tientsin.

ELECTRIC LIGHT IN SPINNING MILLS.—Mr. Charles Lever, of Bowdon, Cheshire, has applied his system of arc lighting to the combing and hanking room of Messrs. Blackburn and Co.'s Clarence Mill. A special Gramme machine is used to maintain six arc lights of 2,000 candle-power nominal. We learn that the light has given every satisfaction.

ELECTRIC LIGHT AND NOVEMBER FOG.—On the occasion of laying the foundation stone of the new National Liberal Club, which is fixed for Tuesday week, 4th November, it is intended to erect a large marquee, and have the electric light ready to be switched on, in case the "London particular" should throw its yellow pall over the proceedings.

ELECTRIC LIGHT AT THE BRIGHTON PAVILION. — The general lighting of the Royal Pavilion, Brighton, is now complete, the total number of lamps being about 1,400. The insurance companies have expressed themselves highly satisfied with the manner in which the work has been carried out by Mr. Magnus Volk, electrical engineer to the corporation.

ELECTRIC LIGHT FOR NEW YORK HARBOUR.—On Monday night the gigantic statue of "Liberty Enlightening the World," that forms the lighthouse at the Hell Gate entrance to New York Harbour, was illuminated by electricity on the Brush system, nine lamps being used of 6,000 candle-power each. The light is regarded as the most powerful in the world.

DOMESTIC LIGHTING BY ARC LAMPS.—We learn that Siemens Brothers have made some small arc lamps, maintained by a current of 40 volts at 10 amperes, and that the light is very steady, thanks to the use of special carbons. A few of these small lights can, of course, be run in the same circuit with those of larger size, and at a far cheaper rate than incandescent.

SHIP LIGHTING.—The steamer "Olympo," built by Messrs. A. and J. Inglis, Pointhouse, for the River Plate service, is lighted by 330 incandescent lamps of 20 candle-power each. An Elphinstone-Vincent machine generates the current; and storage batteries are used to supply 51 lamps for 12 hours while the dynamo is stopped. The lights in the cabins can be switched on or off by the occupants.

PERSONAL.—Messrs. J. E. Spagnoletti and Crookes, electrical engineers and contractors, have bought the business of Messrs. Griffith and Co., Reading, and have removed it to the Adelaide Works, Uxbridge-road, London, W. They continue to carry on the same business, viz., the making of telegraph instruments, blocks, single needles, &c., and also Barnett's accumulator, and are prepared to give estimates for any class of electric lighting.

TELEPHONE ORDERS.—The Consolidated Telephone Construction and Maintenance Company has just received a considerable order from the Portuguese Government for Gower-Bell loud-speaking telephones on the pattern of instruments supplied by the Consolidated Company to the Telephone Company of Austria. The Consolidated Company has also on hand a large order from the United Telephone Company for Gower-Bell telephones for the Postmaster-General.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The general meeting of this company is fixed for the 31st inst., when the directors will recommend the declaration of a final dividend of 3s. per share, payable on 1st November, making with interim dividends already paid, a total payment of 6 per cent. per annum for the year ended 30th June last. £24,000 has been transferred to the reserve fund from the profits of the half year.—The traffic receipts of this company for the week ended 17th inst. amounted to £3,561.

THE TELEPHONE ON BOARD SHIP.—The steamer "Normandie," of the Compagnie Transatlantique, recently took over to the Philadelphia Electrical Exhibition some French *savans*, including M. Berthon, Engineer-in-Chief of the Paris Telephone Company. Some trials were instituted with reference to the practicability of giving orders by telephone on board ship, a line being established between the bridge and the forecastle, and the results showed a marked superiority of the telephone over the speaking trumpet.

OVERHEAD WIRES IN AMERICA.—An Act passed by the last Legislature of the New York State requires that all telegraph, telephone, and electric light wires be removed from the streets before the 1st November, 1885, and that all new wires be laid underground. In the Supreme Court of New York State, Judge Van Brunt has upheld the injunction against the Baltimore and Ohio Telegraph Company, restraining them from maintaining telegraph poles and wires in front of the Clausen Brewery in Second Avenue, New York.

TELEGRAPH OPERATORS' ACCOMMODATION.—The authorities of the Post Office contemplate taking premises in the neighbourhood of Newgate-street, to form a subsidiary branch for the clerical staff of the Telegraph Department, so as to increase the accommodation in the head office for the operative staff. Upon this the *Civilian* reflects that the Government should have acquired a greater frontage in Newgate-street when they had the opportunity; for the building, even with its additional story, is inadequate, and its extension must now be a matter of very great expense.

INSTITUTION OF MECHANICAL ENGINEERS.—The secretary, Mr. Alfred Bache, announces that a general meeting of the institution will be held in the lecture theatre of University College, Nottingham, on Wednesday, 5th November next, at 4 p.m. Among the papers to be read will be one on "The

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Application of Electro-Magnets to the Working of Railway Signals and Points," by Illius A. Timmis, of London. The locomotive works of the Midland Railway, Derby, will be thrown open to members after 10 a.m. on 6th November, by kind invitation of the locomotive superintendent, Samuel W. Johnson, Esq.

A VERY NEW DYNAMO.—We are informed that a new dynamo is in the market, somewhere in the north or south of England, which the proprietors, or their agent, or both, are recommending with a confidence that is somewhat staggering. It appears that all other machines give off an "impure current," which blackens the lamps; whereas with this new invention they "always remain clean." Further, that the wires of existing systems are "decomposed"—probably by "impure" current—whilst theirs remain intact. We believe that the discoverers of these phenomena were in the oil or leather trade, and that they have spent several weeks in the study of electricity.

LONG-DISTANCE TELEPHONY IN BELGIUM.—A recent number of the *Moniteur Belge*—the official journal of Belgium—publishes the royal decree authorising and regulating the long-distance telephoning on the Van Rysselberghe system. It appears that communication has already been established between Brussels and Antwerp, and that it will soon be effected with Ghent, Liége, Verviers, Mons, Charleroi, and Louvain. The tariff is 1fr. (10d.) for five minutes, and 1fr. 50c. (1s. 3d.) for 10 minutes' conversation, the maximum limit; and the rates are doubled during the night. Public offices are established at the Bourse and in the Parc, at Brussels, and at the Eastern Station, the National Bank, the Flemish Theatre, and the "Harmonie," at Antwerp.

AN ELECTRIC LAMP SCARE.—"Just before a ballet at Niblo's Theatre, in this city, one evening last week, a bouquet of crisp flowers hung above the stage, and, lighted by Edison lamps, took fire. A ballet girl, with much presence of mind, immediately seized it and took it off the stage. The flames were at once extinguished, and the curtain rose without the immense audience knowing anything of the accident." We read the above astounding announcement in the New York *Sanitary Engineer* of 9th October. The context leaves us rather in doubt as to what it was the ballet girl took off the stage; but if, as we suppose, the bouquet of crisp flowers is intended, we ask how the dickens they became ignited by the incandescent lamps? As they are said to be Edison lamps, perhaps that distinguished electrician will inquire into the matter and enlighten us.

GULCHER ELECTRIC LIGHT AND POWER COMPANY.—We have received the illustrated catalogue of the Gülcher Electric Light and Power Company, whose system is claimed to afford "a practical solution of some of the difficulties which have hitherto somewhat hindered the introduction of the electric light." Among the principal advantages put forward are the absence of danger to life, owing to the low E.M.F. of the Gülcher dynamo (65 volts); the simplicity of construction of the dynamo and lamps (which we lately described and illustrated); the purity and steadiness of the light due to constant feed; the ability to run arc and incandescent lamps in parallel circuit; and the absence of increased premium demanded by fire insurance companies, as the system fulfils the requirements and conditions laid down by the Council of the Society of Telegraph Engineers and Electricians. The publication of this catalogue at this moment is most opportune, and we commend it to the notice of our readers and the public.

ELECTRIC LIGHT AT THE NEW ORLEANS EXHIBITION.—The managers of the New Orleans Exposition have entered into the following contracts for lighting the buildings and grounds:—The Leavitt-Müller Electric Light Company, 800 arc lamps for the main buildings; the Brush Electric Light Company, 300 lamps for the Government and State exhibit building; the Jenny Arc Light Company, 100 lamps, with five star iron towers for the grounds and the live-stock department; Thompson and Houston, 100 arc lights for the machinery, extension, and saw-mill; Edison Incandescent Light Company, 4,800 lights for the Music Hall, Horticultural Hall, the Art Gallery, State head-quarters, and offices. Each principal entrance and wharf will be lighted by six Leavitt-Müller lamps. Fifteen hundred horse-power is required for the electric-light, which costs the exposition over 100,000dols., or about £20,000.

A MINIATURE INSTALLATION.—A very successful trial of an extremely small electric light plant took place in Manchester on the 16th inst. The steam engine was a pretty little model, with a single cylinder, 3in. diameter and 3in. stroke, driving one of Paterson and Cooper's No. 1 Phœnix dynamos, placed on a sliding foundation. The engine, which has been designed and manufactured by Messrs. Deakin and Parker, of Salford, ran smoothly and without vibration at 480 revolutions, transmitting the power to the dynamo through a Gandy belt. The dynamo, which is compound-wound and has an E.M.F. of 60 volts, maintains 16 incandescent lamps of 60 watts each, and on this occasion was also used to drive an arc lamp, using 16 amperes. This plant, which is interesting if only from its smallness, has been made to the order of a gentleman in Coventry, and will be used for lighting his observatory and billiard room. The required pressure of steam was found to be only 45lbs.

ELECTRIC LIGHT AT THE LAW COURTS.—The Courts opened yesterday, and the electric light was *non est*. Why? Is it the fault of the electrical staff? We should say not, as, from the fact of two large boilers having been lowered into the crypt at the beginning of the present week, it is hardly likely that they could be fixed, connected with the engines, the engines driving the dynamos, and the dynamos maintaining the lights, all by yesterday. We learn, on inquiry, that the electrical department is in as forward a state of preparation as circumstances permit—said circumstances being that one of the large boilers above referred to had to be passed over a space that will eventually be occupied by the dynamos. We hear that the engines are on the rail, so that the electric light will, at any rate, shine out before the end of the year. In the meantime our legal luminaries will have to be supplied with some other source of material illumination.

ELECTRIC LIGHTING AT THE BRIGHTON ART LOAN EXHIBITION.—The large picture gallery has been lighted by Maxim lamps with excellent results, the fact that these lamps will best bear an excess of current having been taken advantage of to produce a whiter light, which shows the paintings with great distinctness. The Corn Exchange, transformed *pro tem.* into an art gallery, has also been lighted by 250 20-candle-power Woodhouse and Rawson lamps, all the electrical work having been carried out by Mr. Magnus Volk. The Exhibition itself is well worth a visit, paintings and works of art, of the gross value of nearly half a million, never before exhibited in public, having been lent freely. It is a point which cannot be too strongly insisted upon that the chief inducement to the owners to lend their property, valuable intrinsically and beyond price from an artistic point of view, was the

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fact that the electric light had been definitely adopted as an illuminant.

THE DEFENCE OF OUR COALING STATIONS.—Under the heading of "What Should be Done," the *Pall Mall Gazette* of last Saturday, in concluding its article on the defences of our coaling stations, puts the following as among the very first things to be undertaken. The writer says:—"The result of this hasty survey is far from satisfactory—if, indeed, it may not be described as alarming. I will therefore summarise what ought to be done: A telegraphic cable should be laid down connecting West Africa and the Cape direct with England. All our telegraphic communication with South Africa passes through Suez, and would be intercepted in case of war. From the Cape, cable communication should be established with India and Australia. A cable should also be laid to Bermuda. The telegraph stations where the cable touches ground should be placed within fortifications; and this of course applies equally to the English end of the cable. At present a single boat's crew landed at Port Darwin could sever Australia from communication with England, and keep all our commanders in the southern seas in total ignorance, until the mails arrived, whether we were at war or peace."

THE NEW SS. "ARAWA."—This splendid steamer, 420ft. in length, 46ft. in breadth, and 32ft. in depth moulded, built by Messrs. Wm. Denny and Brothers, Dumbarton, for the Shaw, Savill and Albion Company, proceeded down the Frith of Clyde last Friday, on her official trial, with a large company on board. A mean speed of 15·31 knots was obtained. The powerful main engines, designed by Mr. Brock, one of the partners of Messrs. Denny, are on the triple expansion principle, supplied with steam at a pressure of 160lb. per square inch, the highest pressure yet reached in ocean going steamers. The vessel is fitted throughout with the electric light, comprising in all 300 separate Swan lamps, the whole of the work of running the leads and fitting the lamps, switches, &c., having been executed by the builders' electrical staff, under Mr. Smillie. Two separate sets of Ferranti plant, of the slow-speed ship pattern, driven direct by Westinghouse engines, were supplied and fitted on board by the Hammond Electric Light Company. The specification for the lighting was prepared, and the official tests were carried out, by Mr. Jamieson, Principal of the Glasgow College of Science and Arts.

THE PRIME MERIDIAN CONFERENCE.—The Prime Meridian Conference at Washington has adopted a resolution providing that the universal day be the mean solar day, and to begin for the world at the moment of mean midnight of the initial meridian coinciding with the beginning of the civil day. It will be counted from zero up to twenty-four hours. There is a hope that it will soon be practicable to arrange that astronomical and nautical days shall begin everywhere at mean midnight. On the motion of M. Janssen, the French delegate, another resolution expressed the hope that technical studies to regulate and extend the decimal system to divisions of the circle and of time would be resumed, so as to permit the extension of this application to all cases where it presents real advantages. *Apropos* of a universal prime meridian and the revelations of "One Who Knows," in the *Pall Mall Gazette*, "Kosmos" advocates the meridian of Rome, once "mistress of the world," being adopted, and adds that those who desire to see chosen the meridian of the nation possessing the largest number of vessels expose themselves to hear said on the morrow of a disaster, "The hour must be changed; the prime meridian has lost its *raison d'être*."

OVERHEAD WIRES.—The General Purposes Committee of the Wandsworth Board of Works, having considered the subject of the proceedings against the United Telephone Company, letters from vestries and district boards as to contributing towards the cost of appealing against the decision in the Court of Appeal, and letter from the vestry clerk of St. Marylebone, stating that, after the decision in the action brought by the Board against the United Telephone Company, it is not proposed to proceed further with the action commenced by the Vestry of St. Marylebone against a telephone company having wires in that parish, recommended that the following vestries and district boards—viz., St. Marylebone, St. James's, Westminster, St. Mary, Islington, St. James and St. John, Clerkenwell, St. Martin-in-the-Fields, and St. Giles-in-the-Fields and St. George, Bloomsbury—be each invited to send five delegates to attend a meeting to be held at the Charing-cross Hotel, with the view of appointing a deputation to present a memorial to the Government, asking them to fulfil their promise to introduce a Bill to confer upon the local authorities control over the erection and maintenance of overhead wires.

ELECTRIC LIGHT AT WORKS.—Messrs. George Richards and Co., who are introducing American types of wood-working machinery into this country, have lately erected some fine new shops, called the "Atlantic Works," at Broadheath, near Manchester. As the roof is arranged at a great height, and the shafting is all carried beneath the floor, they have been enabled to carry out a most effective system of electric lighting, giving a result that would hardly be possible in works of ordinary construction, where the line shafting and belts are all overhead. There are three Gramme dynamos, excited by a smaller machine, for working the 21 arc lights, and a small Phœnix machine for working 30 Gramme incandescent lamps, used in the store rooms, offices, and dining room. In the fitting shops there are 14 Lever arc lights of 2,000 candle-power each, arranged so as to avoid shadows. In the foundry are placed six arc lights, also on the Lever system, and one in the yard. A Manchester contemporary says that the effect of the light is to give a result equal to daylight on a bright day, and a superior light to daylight on a dull or foggy day. The different circuits of the lamps in the workshop, offices, and foundry are driven by three separate engines of small power, so as to permit of their being worked only as required. The plant has been erected by Mr. Charles Lever, of Bowdon; and the results are highly satisfactory, both in working and as compared with gas.

TOLEDO ELECTRIC COMPANY, U.S.A.—The Citizens' Electric Light Company, capital $50,000, which had been doing business in this city for about two years with moderate success, recently became somewhat embarrassed by some claims immediately pressing, so that a change was necessary. Accordingly, within a few days a reorganisation has been effected. The new company, the Toledo Electric Company, with a capital of $150,000, will take the assets of the Citizens and assume the liabilities. President, L. S. Baumgartner; Secretary, F. B. Dodge. The two electric light companies of this place, the Citizens and the Brush, have been rapidly extending their business; but their officers claim they have been doing it at too low rates. Something of a contest has been going on between the gas company and the two electric light companies of this place, especially with reference to lighting the new Cherry-street bridge, and occupying the territory of the sixth ward, East Toledo. When bids were first called for on the bridge, the gas company and the Citizens' Electric Light Com-

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pany put in bids at the same figure, 800 dols. per year. The committee considered this too high and called for more bids, when the gas company failed to respond. The two electric light companies proposed to furnish lights at 60 cents and 70 cents each per night respectively. One of these was recommended by the committee; but the council failed to confirm the contract.—*Sanitary Engineer.*

GAS ON ELECTRICITY.—"The disinterested electricians who are not connected with systems of electrical supply at high potentials have been 'making capital' out of the unfortunate fatality at the Health Exhibition. In this they have been well supported by *The Times*, which has published several letters too slightly distinguished from advertisements for the difference to be perceptible to any one out of Printing House-square. The writers of these effusions have all the same tale to tell:—'It would be unfortunate if popular prejudice should be excited against all electric lighting systems; because there are some which are absolutely harmless,' &c. These people will rejoice because the last fatality in connection with lighting is a gas explosion." So writes the *Journal of Gas Lighting*; and it is almost exactly what in our last week's leader we predicted. We would point out, however, that although a statement of fact may serve as a recommendation—or advertisement if you will—it is no reason why the fact should be withheld. It is a fact that there are electric lighting currents which are harmless, and there is no harm in saying so, if only for the instruction of Gas Lighting journalists. It would be more to the point if the *Journal of Gas Lighting* could say as much for gas explosions. We do not notice that any interested electricians have "rejoiced" at the "latest fatality" for which gas is responsible; whereas there is an evident tone of satisfaction in our contemporary's remarks on the misfortune of its rival.

ELECTRICAL TRANSMISSION AT CREIL.—Last week, in a note on "The Electrical Working of Underground Railways," we quoted from the *Bulletin* of the Compagnie Internationale des Téléphones, and, with reference to the preparations now being made at Creil for the generation of electricity to be transmitted to Paris, asked if our contemporary did not mean that portable engines rather than locomotives were put down for driving the generators. An administrator, or, as we should say, director, of the International Telephone Company has most obligingly sent us the following account of the motive power to be used:—"The two engines put down at Creil for supplying the motive power are two of the Northern Company's ordinary locomotives; they drive an intermediate shaft, which will constitute the starting point of the power in the experiments, and the point where it will be measured. During the experiments, care will be taken that this shaft revolve at a speed about equal to that of the turbines; it will make from 100 to 120 revolutions a minute, while, according to present intentions, the speed of the dynamo-electric machines will not exceed 400 revolutions." This week the *p'tit bleu*—as the company's organ is familiarly styled on account of its complexion, just as the *Globe* was once spoken of by a morning paper as "our blushing contemporary"—says that, in all probability, there will be three receiving machines at the Gare du Nord, Paris, where 20 horse-power is required for the electric lighting; and it is natural to suppose that the current will be taken for the Creil generators. From 30 to 40 horse-power might be absorbed by the hydraulic capstans; and a further 20 horse-power, by the machine-tools at La Chapelle.

THE NEW ATLANTIC CABLE.—The Bennett-Mackay cable was landed at Coney Island at 12.15 on Saturday afternoon; and at 1 o'clock the end was placed in the cable station, being carried through the trench on the shoulders of twenty men. As the end of the cable was dropped on the beach, loud hurrahs went up from a crowd of 200 persons congregated at the entrance of the trench through which the cable passes. The tugs, the locomotives of the Manhattan Beach line, and the "Faraday" blew whistles for several minutes. The general superintendent, Mr. Ward, of the Commercial Cable Co., and the electrician, Mr. Brittle, of Siemens Bros., were heartily congratulated. The landing, according to a *Daily News* telegram, was an entire success, although the wind was north-west, blowing a quarter gale. Telegraphic communication was completed between the "Faraday" and the shore on Saturday evening for the first time. There is now a direct connection between New York and Europe, for the Commercial Cable Company lands almost at the gateway of the city, and carries its cable underground to Wall-street, within two doors of the Stock Exchange. It is believed that this will be an advantage in many ways, the chief of which will be the certainty of instantaneous transmission, without the risk of the delays incidental to land lines from atmospheric disturbances. It will furthermore give the public the benefit of competition, by offering for its use cables outside the Gould combination. It is announced that the new company have applied Muirhead's duplex system to their cables, and have independent stations at all the prominent points in Great Britain, Ireland, and France, and give all these countries the benefit of direct cable communication with New York.—*The Globe.*

TELEGRAPHIC COMMUNICATION.—With reference to communication for outlying portions of the kingdom, the following letter has been addressed, on behalf of Lloyd's Committee, to the Secretary, General Post Office:—"Lloyd's, E.C., Oct. 14. Sir: I am instructed by the Committee of Lloyd's to beg that you will be good enough to inform the Postmaster-General that many more vessels than was formerly the case now make the passage from America round the north coast of Scotland; so much so that, in consequence of the increased use made of this route, Lloyd's have lately established a signal station on the Pentland Firth. It appears that, in case of distress or heavy weather, vessels compelled to put in for refuge on this voyage, when near the coast of the United Kingdom, would probably make for Loch Eribol; and it has been pointed out that at present there is no telegraphic communication with Loch Eribol, so that, when ships arrive there with reports of derelicts or vessels in distress, communication cannot be speedily made with tugowners, shipowners, or underwriters interested; and thus assistance cannot be rapidly sent for the saving of life and property. The Committee of Lloyd's have addressed the Board of Trade upon this subject, and I am to beg that you will be good enough also to bring the matter to the serious attention of Mr. Fawcett. At the same time the committee would wish to suggest that the maintenance of the telegraphic communication of the country as Government monopoly would appear to have prevented the extension of telegraphic communication as widely as might have been expected had the construction of telegraphs been left to private enterprise stimulated by public competition. I am to beg that you will be good enough to move Mr. Fawcett, to allow it to be considered whether some measures might not be taken, by which licenses should be granted to private companies to institute telegraphic communication at their own risk, in districts to which the Government system has not been extended. I am further to remark that it would appear in many countries, which are believed to be financially less prosperous than Great Britain, the benefits of telegraphic

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communication are more widely extended than in this country, as it seems that in Switzerland and Norway there are few villages which are not connected by wire with the telegraphic system of the State."

ELECTRIC LIGHTING IN CARDIFF.—At a recent meeting of the Cardiff Town Council, a report of the Highway Committee was brought up, recommending that the tender of the Great Western Electric Light and Power Company for lighting St. Mary-street with six electric lamps of 2,000 candle-power each, at a cost of £27 per lamp per annum, be accepted. Alderman Duncan moved the adoption of the report; and the motion was duly seconded. The Mayor, however, considered the recommendation condemned by the engineer's report, which stated that the proposed electric lighting would cost £162 a year, against £31 7s., the present cost of gas lighting. Although they would get 12,000 instead of 167 candle-power, this light would not be so evenly distributed. As the gas company had reduced their light by 1s. a lamp, and the price of gas to ordinary consumers by about 6 per cent., so that it was now the cheapest in Wales, and of a quality and purity second to none, he thought it would be better to defer the electric lighting experiment. Alderman Duncan, in reply, thought the present was a very opportune occasion for the council to make a small experiment in St. Mary-street, so that the electric light could be compared with that from Bray's lamps in the High-street. The Highway Committee considered that every corporation, especially that of a rising town like Cardiff, ought to make fair experiments of this kind. He did not think there was any doubt but that the electric light had a great future before it; but unless they made experiments, unless they gave some opportunity for electric light companies to come into the town, so as to see what they could do both in the way of illuminating power and comparative cost, how was the corporation to arrive at a conclusion? As a public body, the council should consider how they could light the town best and at the lowest price; and he thought it was no unreasonable thing for the committee to ask the corporation to expend a few pounds for one year upon an experiment of this kind. The Mayor's amendment, altered as follows:—"That the recommendation of the Highway Committee be deferred until the Corporation have conferred with the Gas Company upon the terms on which they will light St. Mary-street with a light equal to that given in High-street," was then put and carried; and the committee's minutes, as altered, were adopted.

LONG-DISTANCE ELECTRIC LIGHTING.—At the Turin Exhibition, the electrical section of which is international, M. Tresca, curator of the Paris Arts et Métiers collections, has communicated to the *Académie des Sciences* the following facts with regard to the 80-kilometre (50-mile) circuit (including return) established between Turin and Lanzo for electric lighting:—A chrome bronze wire, 3·7 mm. (a full ⅛in.) in diameter, uncovered, conducts the alternate current produced by a Siemens dynamo-electric machine, of the 30 horse-power type, in such a manner that it may be utilised simultaneously for various methods of electric lighting—at the Exhibition itself, at the Turin station, at the Lanzo terminal station, or at the intermediate stations, by its transformation at each point, of the two factors which constitute its energy, by means of new secondary generators exhibited by Gaulard and Gibbs. On the 25th of September, the working was simultaneously found to be regular:—1. At the Exhibition, but a short distance off, of nine Bernstein lamps, one Sun lamp, one Siemens lamp, nine Swan lamps, and five other Bernstein lamps, which necessarily required very different potentials; and 2. At the Turin-Lanzo station, 10 kilometres (6 miles) distant, thirty-four 16-candle Edison lamps, forty-eight 8-candle ditto, and one Siemens arc light. On the 29th September the trials were still more conclusive, the system having been completed to the Lanzo station, 40 kilometres (25 miles) distant, when twenty-four Swan lamps of 100 volts were maintained with absolute regularity. The multiple transformations required by the variety of these various modes of lighting are effected with safety; and, although precise figures cannot yet be given, it is fully proved that the secondary generators must, at any rate within certain limits, be considered as transformers, with a relatively high duty, of the energy of alternate currents. The lighting and extinction were effected, without any disturbance, by means of simple commutators. M. Tresca's principal object was to put on record the complete success of a distribution of various methods of electric lighting over a 40-kilometre (25-mile) circuit (not including return); but these experiments are quite independent of the transport by electric current of mechanical energy, to which the distinguished *savan* has of late directed his attention.

ELECTRIC LIGHT ON MEN-OF-WAR.—It is not often that the *Journal of Gaslighting* has such a good word to say of the electric light as what follows:—"Although, during the last two or three years, electric lighting has made great progress in the direction for which it is pre-eminently suited—the lighting of steamships—very little has transpired as to the cost of this method of illumination when compared with the ordinary method. There are sufficient inducements for the use of the incandescent light on board ship to cast into the background the mere item of expense, even if it should be greatly in excess of the cost of oil. Everyone who has seen the work of the lamp room of a large ship must have been struck with wonderment that more vessels are not set on fire through the necessary provision of means for lighting. A dirty cell, saturated with oil, and littered with oily rags, cotton wicks, and matches, is a real danger on board ship in rough weather and warm climates. Whatever may be the danger of electric lighting currents, it cannot be so great as that of the lamp room. The expense of vegetable oil lamps is also very considerable, as railway companies know full well. Still, it would be satisfactory to learn how the account stands as between oil and electricity; and this idea has struck the Lords of the Admiralty, for in the case of one of the last ironclads fitted with arc and incandescent lamps—the "Colossus," now at Portsmouth—it has been decided to carry out competitive trials of the two systems, for the special purpose of ascertaining the comparative cost. It is to be hoped that the result will be published, and that it will show not only the capital and working charges, but also the cost of breakages; which, in the case of incandescent lamps in a fighting ship, must be serious." The "Colossus" is the only vessel of the first class as yet fitted throughout with the electric light, having powerful search lamps fore and aft, besides 400 incandescent lamps of 10 and 20 c.-p. for lighting the whole of the interior, including stokeholes and coal bunkers. The current is generated by three Victoria dynamos, making only 400 revolutions per minute, placed near the engine room and driven by three-cylinder Brotherhood direct-acting engines. The E.M.F. is only 80 volts, so that no dangerous shock would ensure from inadvertently touching the conductors. The lighting of each portion of the vessel is made independent of the others, and can be controlled from the dynamo room. The whole of the work has been carried out by the Anglo-American Brush Electric Light Company.

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ELECTRICAL TRANSMISSION OF POWER.*

The work produced by a mechanical motor can be converted into electricity by means of dynamo-electric machines, and conversely by the aid of these same machines, which should in this case be called electro-dynamic machines, we can again transform into mechanical work the electric current derived from any source we please. As an example of this, we may take the Gramme machine, and represented diagrammatically in Fig. 1. The current in this machine is universally admitted to be produced by the action of the coils A, passing over the poles N_2 S_2 of the ring. As these coils, with the current circulating through them, approach one or the other pole of the ring, they are attracted by one pole and repelled by the other in such a way that the ring tends to carry the coils round in a direction opposed to that of the motor which turns it, thus absorbing the energy of the motor.

The current produced in machine I. is led into machine II., and flows through the coils of the electro-magnets and the soft iron ring. The result is that in this second machine the coils are similarly repelled and attracted by the now magnetised ring, and the second machine moves round in the opposite direction to the first.

Let the electromotive force of the current produced by machine I. be E_1. The second machine, being precisely similar to the first, itself produces a current as it revolves; let the electromotive force of this current be E_2.

The directions of the currents produced by the two machines are directly opposite, as the machines revolve in contrary

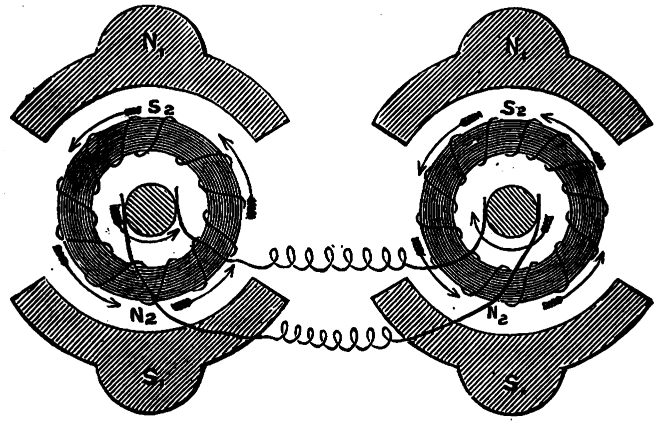

FIG. 1.

directions; the currents accordingly partially neutralise each other, and we obtain in the whole system a current whose electromotive force is equal to $E_1 - E_2$. The work W_1 (in kilogrammetres) expended in machine I. to produce the electric current is, by Joule's law, $W_1 = \frac{E_1 C}{g}$, where g = the intensity of gravity = 9·81, E_1 = E.M.F. of machine I. in volts, C = the strength of the current in the whole system.

Thus $C = \frac{E_1 - E_2}{R}$ = the difference of the electromotive forces of the two machines divided by the sum of the resistances of the coils of both machines and the external conductors.

Now, substituting this value of C in the former equation, we obtain (1)

$$W_1 = \frac{E_1 C}{g} = \frac{E_1 (E_1 - E_2)}{g R}.$$

The work W_2 which is obtained from machine II., and may be described as available work, we can calculate from the formula (2)

$$W_2 = \frac{E_2 C}{g} = \frac{E_2 (E_1 - E_2)}{g R}.$$

The work supplied to the generator is always greater than the available work W_2, as a loss of power occurs owing to the heating of the machine coils and conductors.*

The work expended in heat is by Joule's law (3)

$$W = \frac{R J^2}{g} = \frac{(E_1 - E_2)^2}{g R}.$$

The efficiency K of the power transmitted electrically can now be calculated from the formula,

$$K = \frac{W_2}{W_1} = \frac{E_2 (E_1 - E_2)}{g R} \div \frac{E_1 (E_1 - E_2)}{g R} = \frac{E_2}{E_1}.$$

The efficiency K is thus equal to the ratio of the electromotive forces of the two machines, and thus, with similar machines, similar arrangement of commutators, and perfect insulation of the current, $\frac{E_2}{E_1} = \frac{V_2}{V_1}$, where V_1 V_2 represent the velocities of the two machines respectively. Thus the efficiency K is proportional to the speeds of the two machines, and can in many cases be thus determined.

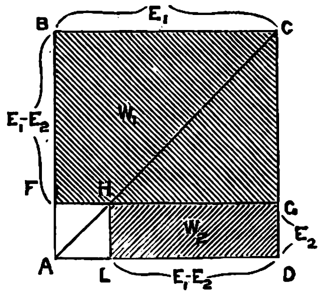

FIG. 2.

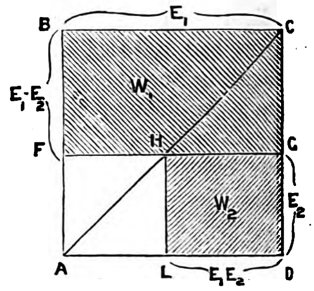

FIG. 3.

The former equation,

$$\frac{W_2}{W_1} = \frac{E_2(E_1 - E_2)}{g R} \div \frac{E_1(E_1 - E_2)}{g R},$$

can be more easily demonstrated by the following graphic method suggested by Professor Silvanus Thompson:

In Fig. 2 let the constant electromotive force E_1 be represented by the line A B, and let the square A B C D be described upon it. From A B cut off A F, equal to E_2, the value of the variable electromotive force, and draw, as in the figure, the lines F G, A C, and H L.

We now have $LD = BF = E_1 - E_2$.

And the area B C G F represents the amount of the work $E_1 (E_1 - E_2)$ absorbed by machine I., and the area L H G D the amount of available work $E_2 (E_1 - E_2)$ obtained from machine II., the constant $\frac{1}{Rg}$, which does not affect the ratios of these amounts, not being taken into consideration.

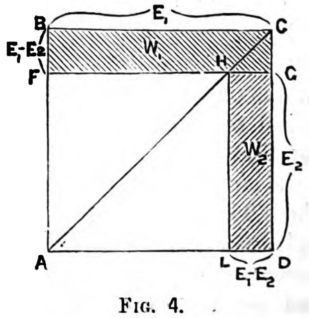

FIG. 4.

It is now evident, on comparing these areas in Fig. 2, that the efficiency, corresponding to the former equation $K = \frac{E_2}{E_1}$, is very small, as E_2 is small compared with E_1.

* Abstracted from an article by Oscar von Müller, in the official report of the International Electrical Exhibition at Munich, 1882.

* A further loss of power takes place owing to the friction of the machine and the existence in the iron of the armature (whether annular or cylindrical) of prejudicial currents, which expend themselves in heating it. Very interesting experiments on this loss of power, which takes place principally in the case of weak currents, have been published by Dr. Fröhlich in the *Electrotechnische Zeitschrift* for 1881, pp. 134 and 170. The consideration of these, however, for the sake of simplicity and brevity, must be omitted from all the following calculations.

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If $E_2 = \frac{1}{2} E_1$ (Fig. 3), the area of F B C G becomes twice that of L H G D; thus the efficiency becomes 50 per cent., and the work obtained from machine II. has now its greatest absolute value.

As the value of E_2 approaches that of E_1 (Fig. 4), though the efficiency is certainly greater, the area L H G D is less than the corresponding area in Fig. 3; thus the absolute value of the available work is less than in the second case.

The amount of work expended in the actual transmission of the power, as also the efficiency, is independent of the diameter of the conductors, provided that where thinner wires are used the electromotive forces of the dynamo machines be increased proportionately to the increase of resistance.

Suppose, for example, the dimensions and speeds of the machines for the transmission of a given force to a given distance, and the proportion of resistance of the coils of the machine to that of the conductor (assuming the cross section of the wire to be of a given dimension) be so arranged that the desired efficiency is produced. Now, instead of the diameter originally used as the basis of calculation, suppose a smaller be selected, so that the resistance is n times as great as before, we have only to increase the electromotive force till it is $\sqrt{n}$ times as much as before in order to transmit the same amount of work with the same efficiency as before.

For by the former equations (1), (2), (3), (4), $W_1 = W_2 + W$, where W is the work lost in heat,

or
$$E_1 \frac{(E - E_2)}{g R} = E_2 \frac{(E_1 - E_2)}{g R} + \frac{(E_1 - E_2)^2}{g R}.$$

If we now employ thinner and longer wire for the machine coils and the conductors, so that the united resistances amount to n R, taking care that in winding the machine with this longer and thinner wire we thereby raise the electromotive forces to $\sqrt{n}\, E_1$ and $\sqrt{n}\, E_2$ respectively, we obtain the equation

$$\frac{\sqrt{n} E_1 (\sqrt{n} E_1 - \sqrt{n} E_2)}{g n R} = \frac{\sqrt{n} E_2 (\sqrt{n} E_1 - \sqrt{n} E_2)}{g n R} + \frac{(\sqrt{n} E_1 - \sqrt{n} E_2)^2}{g n R}$$

which is identical with equation 4.

Thus the increase of resistance affects neither the work absorbed by machine I. nor the available work obtained from machine II., nor the loss of power through heating of the wires, the only result being an increase of the electromotive force, the amount of electromotive force which can be employed with the hitherto invented means of insulation fixing the limit to the increase of resistance.

Deprez employed in the Munich experiments electromotive forces up to 2,200 volts, this being the highest potential hitherto used for electrical transmission of power.

In the Munich International Electrical Exhibition could be seen several examples of electrical transmission of power.

Schönemann worked an autographic press, Schuckert a Zettler's mechanical workshop, and the Société de la Lumiere Electrique Edison a dairy exhibit by means of electrical transmission of power. In these three cases both dynamo-electric and electro-dynamic machines were erected in the exhibition rooms themselves.

A perfectly successful installation over a great distance was carried out by Schukert between the manufactory at Hirschan and the Exhibition. The two electric machines were connected by a copper wire of 10 kilometres long and 4 millimetres in diameter, the machine at Hirschan absorbing about 9 horse-power, while that in the Exhibition supplied about 3 used to work two threshing machines running empty.

The greatest attention could reasonably be claimed for the experiments of Marcel Deprez, who, with ordinary telegraph wires 114 kilometres long, succeeded in the electrical transmission of power to the greatest distance hitherto obtained.

Though the theories of electrical transmission of power, thoroughly developed by Deprez, Frölich, Siemens, Thompson, and several others had been long known to all engaged in the science, Deprez was certainly the first who, acceding to the request of the committee, established, by means of an experiment on a large scale and one intelligible to the general public, the practicability of his calculations on the transmission of power to great distances, though these calculations were frequently considered to be nothing more than interesting scientific speculations. Deprez's experiments have also shown that, if only moderate care be exercised, the much dreaded high potential currents, which must be employed for transmission of power to great distances by means of thin wire, are not absolutely dangerous even in exhibitions, with all the throngs of people and the various manipulations of machines and wire necessary to the carrying out of the experiments.

The machines employed by Deprez in the Murbach at a distance of some 35 miles from Munich absorbed about 1·5 horse-power, while the available work obtained in the Exhibition amounted to about ·4 of a horse-power employed in setting in motion by means of a centrifugal pump a waterfall eight feet in height.

ELECTRICITY AS A NATURAL FORCE.

BY E. L. VOICE.

The writer will endeavour to treat this subject in a manner that all may understand, without the necessity of their having previous electrical knowledge; at the same time, perhaps, some of the remarks may be interesting to scientists.

Faraday's discovery may be classed under two heads: (1) The movement of an electrical conductor round about the pole of a magnet, so as to intersect or cut the external magnetism, thus producing a current. (2) Causing a wire to be under the influence of periodical magnetic change, this change being brought about either by mechanical or electrical means. The latter proposition will only be dealt with in the present article.

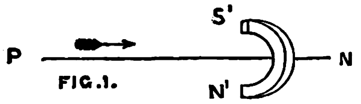

FIG. 1.

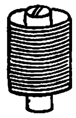
FIG. 2

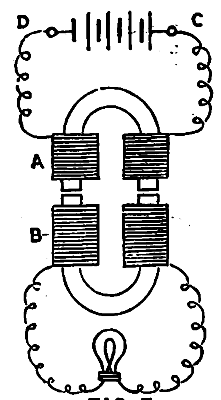

FIG. 3

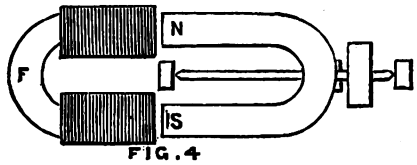

FIG. 4

Let P R (Fig. 1) represent a wire conveying a current in the direction of the arrow, no matter from what source. The wire will be immediately surrounded by magnetism, which may be imagined to consist of a series of magnetic rings or whirls. To make it plain the half of one of these imaginary rings is shown, and it will be seen to resemble a horseshoe permanent magnet, with its two poles N S. In fact, if a piece of soft iron be bent and placed in a similar position, it is rendered magnetic by the action of the current.

From this it may be inferred that an electric current in a wire produces an invisible something round about it. That something is called magnetism. The thought occurred to Faraday that if electricity produced magnetism, then magnetism would produce electricity. He found that it was so, hence his marvellous discovery.

This may be proved by having a powerful permanent magnet at N S. (Fig. 1). If, at a point some distance from the wire, the magnet be moved towards it, say, to the position N S, a current will be generated whose direction will be the reverse of that indicated by the arrow. An *extra* current in this reverse direction also occurs when an initial current from a battery is caused to suddenly exist periodically in the wire. This inverse current or counter E.M.F. plays an important part in the systems to be presently explained.

It has already been said that if an iron rod be bent round

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the wire it is rendered magnetic. The same thing occurs if the rod is straight and laid across the wire. The small area which it covers, however, makes its power very weak; but if the whole length of wire be wound on the rod, then a great power may be developed, and we have an electromagnet (Fig. 2). When a current is passed in the coils of this magnet, the latter will attract masses of iron towards its poles, and cause them also to become magnetic by induction; moreover, if one of these masses be coiled with wire as at B (Fig. 3), it will induce a current in its coil which may be felt by the hands—it may light a Swan lamp. There can be no induced current in the coil B, however, unless the inducing magnet A undergoes a state of magnetic change. This change may be produced by either causing the inducing magnet to periodically lose or reverse its magnetism by breaking the circuit at C, or by reversing the battery connections at C and D. Here, then, a current is induced in the coil B by simply changing the direction of battery current in the inducing magnet A. This is a remark able fact; and, although it is as old as electro-magnetism, time will show it to be one of the chief causes that are destined to revolutionise electricity for industrial purposes.

It has now been shown that a current is generated by mechanically moving a magnet in the neighbourhood of a wire, as at Fig. 1, and that the same result may be obtained electrically by reversing the battery connections, as at Fig. 3.

In 1832 Hippolyte Pixii, of Paris, was the first to apply Faraday's discovery, but it was the mechanical mode of production that he took up. Fig. 4 is a rough sketch of the Pixii machine. The electro-magnet or armature F is fixed,

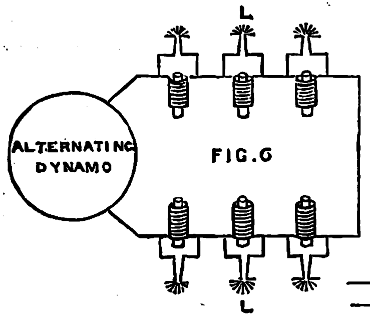

FIG. 6

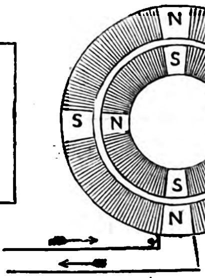

FIG. 5

and is made to undergo a state of magnetic change, and consequently currents are set up in its coils. Now, this change is brought about in this case by pivoting a movable permanent magnet and rotating it by suitable motive power. The induced current, however, sets up a magnetic repelling force to the rotating magnet, and this force, in all modern dynamos, has to be overcome by a steam engine. But what says the sceptic to this?

S. You say that in order to generate a current in Pixii's machine the coils must be subject to magnetic change?—*A.* Quite so.

S. And this change is brought about by the rotation of a permanent magnet before the coils; and moreover you say that this rotation entails a mechanical resistance, requiring in large machines enormous power to overcome it?—*A.* That is so.

S. You appear to have shown that the coil B in Fig. 3 will also develop a current when subject to magnetic change, this result being obtained by simply reversing the battery connections of the inducing magnet A, and requiring practically no mechanical power?—*A.* Quite right.

S. Then it seems in Fig. 3 that the battery takes the place of the steam engine.—*A.* To a certain extent it does; but, assuming the electrical capacity or output of the two machines to be equal, it takes far less power to magnetise the inducing magnet A to saturation than it does to rotate the magnet in the Pixii machine. The whole of the field magnets of modern alternating dynamos are magnetically saturated by the expenditure of two or three horse-power.

S. If all this is true, then why not take the permanent magnet away from the Pixii machine, and put the inducing magnet and battery (Fig. 3) in its place?—*A.* Happy thought!

S. But what about the inverse current? You said just now that any change in direction of inducing current produced an extra current, and in Fig. 3 it seems necessary to be continually changing the initial current. Is it not detrimental?—*A.* At first sight it appears so, but, fortunately, the greater part of this inverse current takes place in the induced coils that form the consumption circuit, in which the lamps may be placed, and is therefore transformed into heat and light. The remainder which exists in the inducing circuit is in no way a mechanical loss to the generator, supposing the apparatus is supplied by a dynamo. There seems be an erroneous impression regarding this inverse current, as if it formed a resistance to the initial current. In reality the two currents are totally distinct from each other, and as they are in inverse directions, the reactionary power which they exert on the armature of a primary generator is as the difference between the two, and is precisely similar to the action of the two inverse currents on the needle of a differential galvanometer.

S. The above machines seem to be well adapted for making an analogy, but for practical application there seems room for improvement.—*A.* Yes. Fig. 5 is a diagram of a recent invention involving precisely similar phenomena. It consists of two circular magnets, placed one within the other. One of the machines may be fixed in each house, and the lamps joined to the inner ring, the outer magnet ring being connected to the main wires in the streets. By an arrangement of movable commutators actuated mechanically the outer magnet is made to rapidly alter its magnetic state, and, in accordance with the above principles, induced currents are set up in the inner magnet for the lamp circuit. The requirements of the Board of Trade are easily followed in this case, inasmuch as the outer magnet may be wound for high tension currents and the inner one for quantity. In this arrangement both the inducing and induced currents are continuous—in fact, it is a continuous current system.

A somewhat simpler arrangement for an alternating system is shown at Fig. 6. A number of electro-magnets are placed in a circuit that is supplied by Gramme, Siemens, or Gordon alternating dynamos; the currents consisting of electrical impulses in alternately opposite directions. The lamp circuit is connected up on each side of each respective magnet so as to enclose it. The electrical resistance of these magnets is very much less than that of the lamp circuits, and therefore the bulk of the initial current passes through them. There is, however, a counter E.M.F. produced in each of the magnets, and this would also tend to expend itself throughout the main circuit. It is easy to see that in a large installation—one with 2,000 magnets, for instance—the resistance of the main circuit would be practically infinite with regard to one of the lamp circuits. It follows, therefore, that the counter E.M.F. finds the path of least resistance by passing in the lamp circuit of each respective magnet, and develops light.

The advantage of these inventions may be summed up in a few words. They demonstrate, both theoretically and practically, that electricity is no longer a mere medium or deputy for the transmission of power, but one of Nature's original forces applicable in endless ways for the benefit of mankind.

[This matter has already been published in a fragmentary form in the columns of a contemporary journal, but as it has been carefully ignored by those who pose as electrical historians, the writer will endeavour to more fully show how the above continuous current system may be practically applied to electric lighting, motive power, the propulsion of ships, railway locomotion, tramcars and tricycles, with a suggestion—a suggestion without much faith—for propelling and steering balloons.—E. L. V.]

Electric Lighting of Hospital Ships.—It will be seen from our advertisement columns that the Metropolitan Asylums Board invite tenders, from electrical engineers and electric light companies, for lighting by electricity the three hospital ships now moored in the Thames at Long Reach, near Dartford, and also the administrative buildings on shore. Mr. J. Hopkinson, F.R.S., M.I.C.E., has prepared the specification, which, with forms of tender, may be obtained at his offices, 4, Westminster-chambers, S.W.

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CORRESPONDENCE.

THE ELECTRIC LIGHTING ACT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The point raised by your correspondent, "Ohm," is one of considerable interest and importance, and I welcome his letter because it is by a discussion of such points that, pending our being able to obtain a repeal or an amendment of the obnoxious Electric Lighting Act, which has proved, for all practical purposes, a dead letter, we may be able to see a way of avoiding some at least of the many barriers to the carrying out of house-to-house lighting, and with this view I venture to submit one or two considerations in regard to the question asked by "Ohm."

The Act of 1882 lays down the conditions upon which compulsory powers to break up streets for purposes of supplying electricity may be granted. It did not extinguish any existing rights, and as many local authorities hold special Acts of Parliament entitling them to break up streets for various purposes, it is, I think, an open question whether they have not this right for purposes of electric lighting. Whether or not this right is possessed by any particular local authority is of course best determined by a legal adviser acquainted with all the local circumstances. The Public Health Act alone does not authorise any one to break up the streets for these purposes. It states that "any urban authority may contract with any person for the supply of gas or other means of lighting the streets, markets, and public buildings in their district," and the person who so contracts for the supply of the means of electric lighting would undoubtedly have to provide himself with a license or provisional order, unless (as I believe is the case in many instances) the local authorities are able to maintain that they have the power to break up the streets for this purpose independent of the Electric Lighting Act, and are prepared to give the contractors the benefit of this right.—Yours, &c., E. G.

Oct. 23, 1884.

A CURIOUS CASE OF INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am not sure that I understand "F. L. C.'s" letter—that part of it about "summoning a man" being rather obscure; but if he means that voices were reproduced by the microphonic portion of his apparatus, this is by no means a new although still a curious phenomenon. It has been contended, from almost the very first discovery of the microphone, that it not only transmitted sounds but accurately reproduced them; and several receiving telephones have been constructed on this principle, their non-adoption in practice being due to their comparative feebleness for want of that resonant element which a diaphragm supplies in the magneto telephone.—Yours, &c., J. L.

London, 20th Oct., 1884.

HONOUR TO WHOM HONOUR IS DUE!

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The following extracts are from a letter addressed to the editor of the Melbourne *Argus*, and printed in the issue of that paper for July 23, 1884:—

"You were good enough to insert, in November last, a letter from me on Dr. Davy's early connection with the electric telegraph; and other letters on the same subject followed in your columns. Mr. Ellery, the Astronomer Royal, read on November 15, before the Royal Society (of which he is president), an eulogistic paper, after which the Society conferred on Dr. Davy the distinction of honorary life membership . . . . .

"Dr. Davy's friends are not content that the matter should rest here; and Mr. C. Young, the member for his district, has kindly and most readily promised to ask the Legislative Assembly at once to appoint a committee to inquire into the validity of the Doctor's claims, with a view to making suitable representations to the Imperial Government.

"The House will, no doubt, for the honour of the colony, and in the interests of an old and respected colonist, gladly grant such an inquiry. Dr. Davy has, we may well suppose, at the age of 80, arrived near the end of life's journey; and if anything is to be done for his personal benefit it should be done at once."

Dr. Davy's claims to our recognition have been so recently set forth by me, in Vol. XI. of your journal, and in Chapters XIII., XIV., and XV. of my "History of Electric Telegraphy," that I need not recapitulate them here. In the early days of the electric telegraph, 1836-39, Dr. Davy was, to use Mr. Latimer Clark's expressive words, "neck and neck with Cooke and Wheatstone;" and had not circumstances compelled his withdrawal from the race, when almost in sight of the goal, he would, without doubt, have shared with them the prize. As it is, Cooke and Wheatstone have had riches and honours showered upon them, and have died leaving behind them imperishable names, while Edward Davy lives —but how?, unknown and unhonoured, outside a small circle of colonial friends, dependent for his subsistence on the drudgery of an up-country doctor's practice in a far-off colony. So for forty-five years he has been content to live, and so would he have been content to die; but his early inventions and discoveries in electric telegraphy having lately come to light, his fellow colonists have determined, even though it be the eleventh hour, to do him all the honour they can, and to make easier the last years, it may be days, of the venerable pioneer.

Some recognition on the part of the telegraph engineers of England would now be useful, as it would strengthen the hands of Dr. Davy's colonial friends; and it is with a view of eliciting this recognition that I write these lines.

As long ago as last October (1883) I brought Dr. Davy's case before the council of the Society of Telegraph Engineers and Electricians, but—but, no decision has yet been come to.—Yours, &c., J. J. FAHIE.

Teheran, Persia, Sept. 29, 1884.

LIGHTNING CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you kindly favour me with your opinion if, in fixing a lightning conductor to a church tower, it is either safe or proper to secure it to the *gas* main, and that only some six inches underground. It is only about six years since the church (a new one) was totally destroyed by fire within a fortnight of the flues being tampered with, and now the vicar &c., appears to be inviting another disaster.

A reply in your columns or otherwise will greatly oblige.—Yours, &c., A SUBSCRIBER.

[It is neither safe nor proper.—ED. *E.*]

TELEPHONY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to "Curiosity's" letter in your impression of the 4th of October I would refer your correspondent to the *Dundee Advertiser* of the 16th and 17th September, 1884, containing two lengthy illustrated articles on the telephone, which will give him all the information he can require.—Yours, &c.,

3, Great Winchester-street, E.C., E. A. B.
4th October, 1884.

A LEGAL QUESTION.

A subscriber writes us:—"Some three years ago I purchased a few transmitters of the Gower-Bell type. Can I legally use these, as they were bought long before Edison sent in his disclaimer?"

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

ANSWER TO CORRESPONDENT.

A. H. P. (Cyprus).—*Write to 14, Rue Vivienne, Paris.*

CONTENTS.

Notes 525
Electrical Transmission of Power. Illustrated 530
Electricity as a Natural Force. By E. L. Voice. Illustrated 531
Correspondence 533
One Phase of Cable Maintenance 534
The Theory of the Dynamo-Electric Machine. By Professor Rowland. (Continued.) Illustrated. 535
On the Permanent Temperature of Conductors. Illustrated 538
Submarine Cables in War Time 540
Elwell and Parker's Patent Engine. Illustrated 541
The Roussy Electric Light Moderator. Illustrated 542
West African Cable 542
Companies' Meetings—
The West India and Panama Telegraph Company 543
The Telephone Company of Ireland 544
Brazilian Submarine Telegraph Company 544
Companies' Share List 544

ONE PHASE OF CABLE MAINTENANCE.

An ever-recurring question is found in the true relation between the mother country and her colonies. We strongly suspect, however, that no Englishman is content to think of any colony except as an integral part of the Empire. During the parliamentary recess attention has been called to the state of our navy—its unpreparedness, weakness, and inefficiency to protect our commerce. It has been shown that not only is our navy numerically weak, but that in case of war it would be further weakened in that most of our coaling stations are wholly at the mercy of an active, enterprising enemy; and there are many gaps in the continuity of telegraphic connection that should be remedied before the evil day arrives. All such discussions are valuable and interesting, but at the same time we must not be led away with the idea that the main object of ocean telegraphy is for military and political purposes. So far is this from being the case, that almost without exception cables have been made, laid, and are maintained more directly in the interests of commerce, and are only indirectly connected with military purposes. Assuming, then, that the direct object of cables is to promote commercial intercourse, while at the same time they are almost invaluable in political affairs, the question of their maintenance in good working order is one of the utmost importance. One phase in the maintenance of cables has only during the past year or two become prominent, but it is one that, in certain positions and under certain conditions, will rapidly overshadow all others. The right time to consider the whole question is before it becomes "urgent."

A cable is the property of its owners, just as a house or an estate, and the owners can recover damages from anyone wilfully injuring their property. There are many ways of injuring a cable without cutting it, and one of these has not yet received the consideration it deserves, viz., the laying of one cable too near or over another in such depths as there can be no certainty of recovering one without injury to the other. Consider for a moment the work of repairing a cable. Far down below the surface—a thousand fathoms deep, lies a thread some inch or so in diameter. This thread has to be caught by the grapnel and brought to the surface. Given every assistance—the fullest knowledge of the sea and its surface currents, the configuration of its bed, the atmospheric conditions, yet still the operation is uncertain, difficult, and dangerous. But the knowledge is generally far from perfect. The exact position of the cable is unknown, it may be miles, more or less, from where it is supposed to be. The course of the ship while grappling may be affected by currents, and instead of being at right angles to the line of cable, it may be parallel to—or at some other than a right angle. In laying a cable across the Atlantic the ship does not stop paying out because of unfavourable weather; yet this or surface currents may cause a long deviation from the course it was intended to keep. We have said sufficient to show that exactness is out of the question. A repairing vessel arrives upon the ground, and grapples over a course of five, ten, or twenty miles backwards and forwards to find the cable. Suppose two or three or more cables to be laid parallel, or are supposed to be parallel, to each other at five or ten miles' intervals, it is doubtful if the best equipped expedition ever sent out could, except by chance, grapple for a certainty one of these cables. The probability is that in attempting to find one the doctrine of cussedness or contrariety would step in, and while the one wanted would not come on the grapnels, the others not wanted would be caught, and, being caught, would be rendered for the time useless. This is no imaginary case—it has occurred—nor is it the worst case. What but disaster can happen when cables are laid over cables in deep water? The Atlantic can show more than one example of this. Let one of these cables develop a fault near the crossing point, and in the repair it is absolutely impossible to get the faulty cable without injury to the other. At the present time there are seven Atlantic cables laid at several points in such proximity, parallel one to the other, overlaid and crossed where the depth of water is very great, making it almost certain that whenever any one of these cables has to be repaired one or more of the others will be broken. The outlook to the shareholders is not good. The legal aspect of the case is fairly simple, but there is no doubt the question of injury must be decided before the legal tribunals. A concessionaire, A, has a right to lay a cable from Europe to America, so has B, but has B any right to lay his cable to the certain material injury of the cable of A? One man has a right to build a house; that being built, he has certain rights that cannot be ignored by B when building an adjacent house. The loss to a landlord is hardly comparable to the three-quarters of a million or a million which represents the loss of a cable; and the more the question is examined the more certain becomes the fact that cables crossing in deep water present almost insuperable difficulties in the way of repair.

Surely the question now to ask, and the problem to solve, is what international law or restrictions should be framed to regulate the laying of new cables. If communication with every part of the world is felt to be so important politically,

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this question can hardly be allowed to rest before being finally settled. The loss to owners may be bad enough, but it is easy to foresee how infinitely greater might be the loss to civilisation if, some day, in the midst of political troubles, communication with America ceased. It is not a question of giving monopoly to existing companies. It is in the general interest of the public that the existing means of telegraphing should not be needlessly endangered. The Governments concerned in the concessions are all-powerful in the matter, in that they can make it a condition of the right to land cables that they shall be laid so as not to endanger existing lines. Such questions, so far as England is concerned, might well be determined by the Board of Trade, inasmuch as they involve neither technicalities nor other difficulties. Existing cables must, it seems to us, take their chance of interruptions; yet we think much costly litigation will be avoided if some agreement is come to by the companies interested. The law governing the protection of submarine cables is contained in the Convention signed last March at Paris. Two of the Articles in this Convention may be quoted as referring to the subject now under discussion. Art. II. says "It is a punishable offence to break or injure a submarine cable wilfully or by culpable negligence, so as to interrupt or obstruct telegraphic communication either wholly or partially . . ." Art. IV. reads, "The owner of a cable, who in laying or repairing his own cable breaks or injures another cable, must bear the cost of repairing the breakage or injury without prejudice to the application, if need be, of Art. II. of the present Convention."

We may sum up the whole question thus. It is admitted that the laying and maintenance of submarine cables is of the greatest importance, commercially and politically. At the present time the indiscriminate manner of laying the Atlantic cables has led to several cables being in close proximity, crossing one another in deep water, so that it is impossible to repair any one cable at these points without damaging one or more of the others. The remedy we suggest is an international agreement to refuse the rights to land cables unless the cables are laid at such a distance and in such a manner as not to jeopardise the maintenance of other cables; and further that no delay should occur in obtaining this agreement.

THE THEORY OF THE DYNAMO-ELECTRIC MACHINE.*

BY PROFESSOR ROWLAND.

(CONTINUED FROM PAGE 518.)

This machine has two magnets, one above and one below. The lines of force pass up there (*a*) and then out through here (*b*) and then up through there (*c*). These outside pieces (*d*) instead of being far off, are down close. Here is one pole of the magnet near this piece. The lines of force instead of passing across the field of force as they ought to do, pass off here (arrows). The circuit cannot go around, for it would go down and across this opening and up that way (arrows). In this case there is loss, due to the lines of force leaking out; and if these pieces are too near, the lines of force will pass across that opening instead of passing across the opening where the wires revolve; so that there will be a loss, and we shall have to enlarge our magnet, and therefore have more energy expended in keeping up the magnet. There is energy expended in keeping up the field outside as well as in keeping up the field of the magnet. So with respect to this machine it is important that this point should be considered. In this form of a machine (Fig. 3) where there is a small circuit, this magnet has to be attached somewhere. They usually put on a piece of brass across the poles to attach it to. Very often this magnet is turned vertically in the way shown, and then the whole thing is attached to a cast-iron bench. I have no doubt that considerable lines of force are lost in passing across this magnet to this iron piece. I do not think much is lost at that point, but some is lost. The makers of the machine, I suppose, considered this to some extent, but what is needed is measurement on that point.

How many lines of force go across the armature opening and are effective in producing the current, and how many escape and are lost?

These questions are just as important as the question of the leakage of the current in the wire?

There are defects in many of these machines in that respect. By the way, in this last form, some people may say the putting this here and there (indicating *d d*) adds to the strength of the magnet. It does undoubtedly add to the strength of the magnet, but those are useless lines of force that pass across here (arrows). If you measure it here the strength is increased, but you do not increase the strength when you take into consideration the loss.

Here is another form of magnet (Fig. 7). That machine would be defective. It has two magnets in the place of one, and it has two magnetic circuits in the place of one, and many of the lines of force probably make little private circuits of their own around in that way (arrows). Those lines of force are of course lost, and therefore it is more or less defective in that respect. There are machines which this figure represents exactly, but it is not meant for any particular machine; it is meant for a scientific drawing.

I am only giving a general idea of the principles of these machines, and I do not refer to any particular machine. It is also important that this line of magnetic induction shall find easy passage around in order to produce the most intense field. Suppose this was the pole *c*, then the opening at the sides must be made as wide as possible; everybody recognises that! The reason for it is, in order that the lines of force may find easy passage across this opening (*c* to *c*).

Suppose we had a machine made in the following manner (Fig. 8). I don't want to say that it is anybody's machine—I may not have made the drawing right—but suppose there was such a machine, and that somebody did make it, in which there was a magnet with a Gramme ring here (*a*), pole-piece here (*b*), one ring here (*c*), and pole-piece here (*d*), but not any on the other side. How are the lines of force to pass? They evidently go around here (arrow) and strike into the Gramme ring, and I suppose pass across the opening here (arrow), and go to the other side the best way they can. You see there is no easy passage for the lines of force in this case.

I have here a formula for the amount of work which one has to put upon a magnet to produce a certain effect. I will take the case which I have considered most efficient, where there is one magnetic circuit. Here you will have the lines of force going around this machine in this manner (see arrows, Fig. 3). The reason they go thus is from what I have sometimes called a magneto-motor force. It is not a very bad term to be used. It is an original idea of Faraday that these lines of force are conducted by a metal. We suppose these lines of force pass (as shown by arrows), and then they have to pass through the iron and across the opening, and are caused to do that by what may be called the magneto-motor force of the helix. The magneto-motor force of that helix is proportional to the number of coils around the magnet and proportional to the current C in the wire. I will not write down the exact expression for this quantity; I will only say the magneto-motor force is proportional to N, the number of turns around the magnet, and C, the current. The number of lines of force which pass around here we may call B. This is not the quantity which Maxwell considers, but it includes the whole number of lines of force which pass through the magnet. We may write B proportional to N the number of turns of the wire, and C the current, and inversely proportional to the resistance of these lines of force in going around this circuit. The resistance of the lines of force is proportioned to L, the length of the iron

* A paper read at the Congress of Electricians at Philadelphia.

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of the system, divided by S, the surface cross section of the magnet, supposing it to be a uniform surface, into ϕ, the magnetic permeability of the iron (or you may call it the conductivity of the iron for the lines of force). This quantity ϕ varies with the current, it can readily be obtained; indeed, some years ago, I gave a formula for it. It can be expressed simply as dependent upon the magnetism of the iron and a constant depending upon the iron alone. Then to this we have something more to add.

Let l be the width of this opening (indicating) and A the area across which the line of force flows; then we have to add l ÷ A, we have still to add to this a certain quantity which we can call p, which depends upon the resistance of these lines of force which escape in all directions. It represents loss due to the escaping of the lines of force. Thus we have the final value for the magneto-motor force,

$$\frac{NC}{\frac{L}{S\phi}+\frac{l}{A}+p}.$$

This gives us an equation which may be solved with respect to ϕ. It is evident that the curve for the magnetic permeability is of this nature.

It rises to a maximum here and then decreases. It will not rise as much as this diagram (Fig. 9) indicates, but it will be a more flat form, according to the value of l and p. Therefore, increasing the magnetic force on your magnet, a certain point will be arrived at where it becomes very easy to magnetise a magnet, and after that it becomes harder and harder to magnetise the magnet. So that in practice you should get the form of this curve, so that it should produce a very strong

Fig. 9.

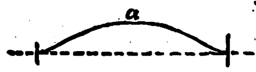
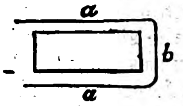


Fig. 11.



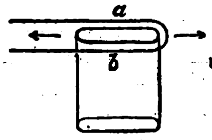


Fig. 10.

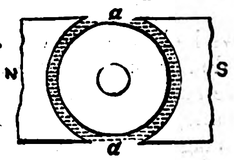


Fig. 12.

magnetic field. This can only be done by an exact calculation, or, better, by experiments on the machines, examining at each point the forces of the current, and in that way getting an idea of how these lines of force go, and we can then see whether this area is large enough to take all the lines of force necessary to pass.

I have here an expression for the work necessary to keep up a proper field in the magnet. Of course as you coil the wire on these magnets, the coil becomes thicker and thicker, and in order to have a sufficient magnetic force across this opening with sufficient velocity you must have sufficient wire. As you increase the thickness, of course you have to use more wire for a certain core. Every core acts very nearly the same as every other in producing force; therefore, if you have the magnets very short indeed, you have to pile up your wire to a very great extent. The wire is made of copper, and as iron is cheaper than copper, it might be better to lengthen out the core slightly. I suppose you would lengthen out the core until the given length of wire on the magnet may make a moderately thin layer. Of course, as you lengthen out your magnet the resistance of this circuit to magnetisation becomes greater; but that is a very small quantity, and I do not suppose it increases much, even for a considerable lengthening of the magnet.

As I said before, the magnetic conductivity of iron is many times greater than that of air, and we can lengthen out the cores without producing much loss on account of that lengthening. Some persons have suggested that there may be a slight gain from the fact that iron, after it has been magnetised a great number of times in the same direction, rather likes to be magnetised in that same direction afterward. If the core is made of any material similar to steel, such as wrought iron or anything of that sort, it might be possible to have some gain from the coercive power of the magnet. There would be a loss from that cause—you have to act against the force of the magnet at first—but, from the continual use of the machine, I think very likely the iron might get a set in the direction of the force, which might possibly aid in the production of a suitable dynamo. If the core was of steel it is evident that you could send a strong current through at first, and magnetise the steel and then diminish the current slightly. We could thus still keep up a very large force at this point and with a moderately small current. I do not know how practical that would be, but it seems to me that it would produce a very strong field. In the commencement of the operation we should have to send a powerful current to magnetise the steel, and then, without stopping the current, to diminish it; then the force of the steel would be in the same direction with the current, and produce the field with less expenditure of energy than if it were simply iron.

As far as the difference between a shunt machine and a series machine is concerned, there is no difference. The magnetising force of this magnet is proportional to the number of turns multiplied by the current; that is, proportional to the cross section of the coils multiplied by the current per unit of the section, so that the magnetising action can be the same with a machine which produces a strong current and a machine which produces a weak current. If you calculate the energy, you will find it is the same, because it depends upon the current into the cross section. If the exterior dimensions of the coils are the same in both cases, the same energy is expended in each; in order to produce the same force, therefore there is no difference between a shunt machine and a series machine. I think the energy will be the same for both. I will now refer to the heating of the armature. Of course the amount of energy expended in the heating of the armature will be dependent on the resistance of the armature, and the efficiency of the circuit will merely depend upon the relation between the resistance of the armature and the exterior resistance; that is very well known. There is one other point: There is a certain lot of dead wire, you may call it—I do not know the technical term; I think very likely that that is the technical term. In the first place, I will only discuss the Gramme and Siemens armatures. In the Gramme machine you have the armature inside of the ring, and the ends do not act at all. In the Siemens armature, we have the coils brought over the ends of the armature. It is only a question of the work of the machines and the relation between the two. In the Gramme machine, it must be that less than one-half of the wire is acting. You have the section of the Gramme ring (see Fig. 10), and when that portion, a, of the wire is active, of course this portion, b, is dead. I suppose some of the lines of force go out here, as shown by the arrows, so that we can see at least half the wire is dead wire.

In the Siemens armature one cannot say immediately how much dead wire there will be, because it depends upon the length of the armature. In the Siemens armature you have the wire wound (as shown in Fig. 11), and this portion, a, would be active and this portion, b, dead. Of course, if the armature is very thick you would have more dead wire than when it is simply long. I cannot say which has the more dead wire, but I dare say the Gramme has more than the Siemens. Furthermore, either in the Gramme ring or the Siemens armature—I will draw this figure to represent either the Gramme or Siemens armature—you have the lines of force running (Fig. 12) as shown in dotted lines. That portion is active, and this portion, a, in between the poles is dead; and when the thing revolves you have the lines of force turning around, and I think that would add more dead wire to your machines. I believe an attempt has been made to throw out these dead coils; I believe in some form of machines they are thrown out. There is no necessity to go further. Of course the efficiency of the circuit depends upon the ratio of the resistance of the armature to the resistance of the wires, and therefore, as far as this point is concerned, any machine can be just as efficient as you please by putting in greater and greater external resistance. But as the magnet

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remains the same, you would find a point where the efficiency of the machine as a whole would not increase for an increase of external resistance, and the work would actually diminish.

There are other things to be taken account of; there are some losses due to the self-induction of the coils which produce sparks in them. I have requested Professor Fitzgerald to take up that point, and therefore I will leave it for him to consider. Now to consider another point with regard to the dynamo which can be treated in this simple manner with no use of the calculus. I think it can be done by very simple reasoning, if you only know the principles. I shall now attempt to construct two machines similar in all respects, but one of which is larger than the other. We can suppose that we construct one of the machines, and then see what the effect will be when that machine gradually grows and becomes very large.

The point we shall start from is that the magnetic field is constant in the two machines. Owing to the fact that there is a limit to the magnetisation of a magnet, we cannot have a field which is produced by iron, with more than certain strength. Therefore, I suppose that you get up to a reasonable strength with your iron. It cannot be up to the maximum strength, of course, but it is somewhere near it. I made some experiments many years ago upon an ordinary magnet (and the results were published, I think, in *Siemens' Journal*). It is beautifully applied to the dynamo machines, and I obtained everything with it that I have referred to here. With that apparatus, if I remember rightly, I got about one-third of the force in the field of a magnet that iron could possibly give. Of course, you could get greater. It is theoretically possible to get a force equal to the magnetisability of the iron, or the maximum magnetism of the iron; but, practically, I suppose the case is very similar to that of the ordinary dynamo machine. Therefore, we can say that the field of force in the two machines, one of which is larger than the other, shall be constant, and I will therefore write down F constant.

It is not only constant in one part of the machine, but in all parts; the magnetising force at every point of one machine is equal to that in a similar point in the other machine. Therefore, if you drew the machines on the board, it would not make any matter about the scale of dimensions of the machine; you could mark down the force at a certain point as being a certain amount, and consider the scale whatever you please.

Starting from that point, we will consider what must be the current in the wire in the two machines. The machines have the same number of turns around the magnet, and everything is the same except the dimensions of one machine are greater than the dimensions of the other. I will give you a formula for the current in the wire. Suppose you have a tangent galvanometer. Consider the current passing around its coil. If you make the circular wire of the galvanometer grow, in order to produce the same effect at the centre you must add current in direct proportion to the radius of the coil. If you make that coil twice as large, you must have the current twice as large in order to produce the same force at the centre, and not only at the centre but at every point. If the material is constant, if there is no difference in the iron, we have the current in direct proportion to the linear dimensions of the figures, so that the current in the wire varies as the linear dimensions of the machine. Make one machine twice as large as the other, and the current per unit of area in the magnet must be twice as great to produce the proper motive force. Of course the wire has increased in size. If the machine is increased to twice its original size, the cross section of the wire is increased four times. In other words, from that cause the current per unit of area will vary inversely as the square of l, the linear dimension; and since we have found the current to vary directly as l, in order to retain the same force in the field by a combination of the two results, it varies inversely as l. Therefore, as far as the magnets of a machine are concerned, if the machine grows larger in this way, its heating effect, which depends upon the current per unit of cross section, will be less, since the surface will have been increased in proportion to the square of l. There will therefore be less danger of heating in a large magnet than in a small magnet. This is only with respect to the magnet. In some cases it is practically found harder to run a large machine than a smaller one; but we shall find how that comes.

The resistance of any part of the machine and the work of the armature varies, of course, directly as the length of the wire and inversely as the cross section. The cross section varies as l square, so that the whole work varies inversely as l, or the resistance varies inversely as l. Therefore the larger you make the machine the less the resistance will be; one machine being twice as large as the other, the resistance will be half as great.

I will now consider the electromotive force. This applies not only to the work of the magnet but also to the work of the armature. We have here the current and the resistance. The electromotive force is proportional to the product of the current and the resistance, hence we may write $E = RC$. Therefore the electromotive force of this machine will be constant. We shall presently see how this is modified so as to get the electromotive force greater for the larger machine. The work done is therefore equal to $C^2 R$ in any part of the machine, or in the whole machine just as you please. But that quantity varies directly as l, the linear dimension. Therefore the one machine, which is twice as large as the other, requires twice as much power to run it, and you get twice as much electrical energy out of it. But it is to be remembered that the weight of the machine varies as l^3, and you have only got l times the work out of it as constructed in this way.

Let us see what the reason of this is. The field of the magnet is the same. There are just as many lines of force in the armature in the two machines, and when we calculate up, we shall see that the angular velocity of the armature or the number of turns per second or minute must vary inversely as l^2. In other words, in one machine twice as great as another, the velocity of the armature must be only one-fourth as great in order to produce the same current in the wires. This takes account, I think, of every irregularity in the machine—the two machines are exactly alike in every respect. I have not added the loss for the self-induction of the coil.

So far as the results go, we have constructed two machines which differ only in size. The efficiency of these two machines is a constant quantity. That will be rather startling to some who come to me constantly and say "a larger machine is more efficient than a smaller one." As far as this thing goes, we have constructed a machine which is larger than another, and in which the efficiency is the same.

Let us see the cause of the efficiency remaining constant. On what does the efficiency depend? We have got to keep our magnetic field the same in both cases; and therefore work done in sustaining the magnet will be this $C^2 R$. But here we have the angular velocity inversely as the square of the linear dimension. The question comes up again, whether we cannot increase the velocity of the armature above that point. Is it practically necessary that we should run one machine at one-fourth of the velocity if it is twice as large? It is a practical question as to what we can get. I should think it certainly was not in this proportion. I should think it would be more nearly inversely as the square of the size. Can we not then run the machine with greater angular velocity? We certainly can do so by increasing the external resistance, so that the same current flows when you run it fast as in this case. Then the driving force will be the same, and the whole machine will be increased in efficiency. We can certainly do that to a certain extent—I do not know where it will end practically—but starting with a small machine without increasing the electromotive force, which is constant in these machines, but by arranging the wire of the armature so as to increase the external resistance, we can increase the speed and yet have the current per unit of section through the armature the same as in this case. If we do that, we shall be able to increase the external resistance of the machine in comparison with the resistance of the armature, and when we do that we increase the efficiency of the machine.

I think it is from this cause that we find large machines more efficient than smaller ones. But it is also evident that there is a limit, which can only be obtained, I suppose, from practically making the machines, and seeing how fast they

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may be run without flying to pieces. If we can keep them going at a greater rate of speed than I have pointed out as they are increased in size, I suppose the efficiency will be increased.

As far as this theory goes, the increase comes not from the size of the machine but from the fact that you can get a greater electromotive force with the same angular velocity, and so can increase the external resistance in proportion, so that you find in very large machines you can make the wire with one turn around the armature—not several turns—just have bars on the machines. We thus decrease the resistance of the machine and at the same time we run it above this relation which I have pointed out and so obtain the proper electromotive force. The proper electromotive force is more easily obtained from the large than the small machine, because it is not practically necessary to decrease the velocity.—*Electrical World.*

ON THE PERMANENT TEMPERATURE OF CONDUCTORS.*

The experiments of which an account is given in the following paper were commenced several months ago in connection with a theoretical investigation by Sir Wm. Thomson, "On the Effect of Clothing," showing the dependence of the effect on the relation between the dimensions of the covered body, and the dimensions and physical properties of the covering. A primary object of the experiments was the determination, for practical purposes, of the temperature of electric light conductors. The preliminary experiments have led to results which seem to be of considerable importance, and they point to the necessity for a fresh determination of the "emissivity" or "surface-conductivity" of bodies of various dimensions, and under various circumstances as to surroundings and as to air pressure.

With respect to the determination of the permanent temperatures of wires carrying electric currents very little seems to have been done experimentally. In fact, the only important experiments on the subject seem to be those of Mr. Preece, on the currents required to fuse and to raise to a dull red heat platinum wires of different diameters. These were communicated to the Royal Society in a paper read April 3, 1884. I may here remark that the results given by Mr. Preece differ in a very definite way from those which I have obtained; but it is to be noticed that the temperatures of Mr. Preece's determinations were much higher than those at which I have, up to the present, experimented.

The method which I have employed for determining the heating effect of a given current in a given wire has been to find the *resistance* of the wire, first with a very feeble current passing through it, and afterwards with the given more powerful current passing, and after it has been passing for a sufficiently long time for the wire to have acquired a temperature permanent under the given circumstances. The resistance of the wire becomes increased as the temperature rises, and from the increase of resistance the increase of temperature can be calculated.

In doing this I have used two methods of experimenting. In the first method the wire under experiment was connected in series with the battery supplying the current, an amperemeter, and a standard resistance of thick German silver wire. The German silver wire was immersed in heavy paraffin oil to keep it cool, and the wire under experiment was left freely exposed to the air, but carefully guarded by paper screens placed at safe distances, both from draughts and currents of air, and from radiation of the sun or laboratory fire, and from the persons of the observers.

To commence the experiment a very feeble current was passed through the line consisting of the copper and the German silver wire, and by means of a sensitive reflecting galvanometer of high resistance the differences of potentials at the two ends of A B, the copper wire, and of B C, the German silver wire, were determined (Fig. 1). The ratio between these differences of potentials is the same as the ratio between the resistances of A B and B C. Then, B C, the standard of German silver, being known, the resistance of A B was calculated. This experiment, therefore, gave the resistance of A B *cold.*

A much more powerful current was then caused to flow through the line, and was kept up for a sufficient time until A B had taken a permanent temperature. The terminals of the potential galvanometer were again applied, and the differences of potentials at the extremeties of A B and of B C once more determined, and thus the ratio of their resistances. If the resistance of B C had remained absolutely constant, the resist-

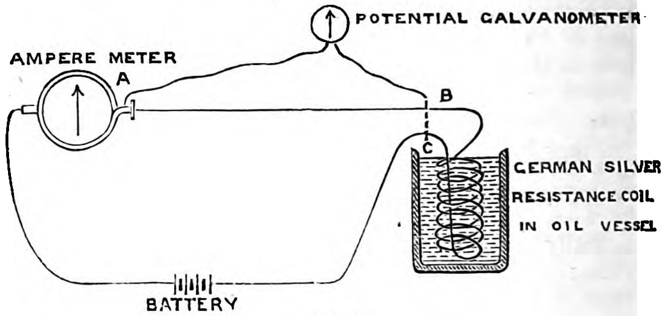

FIG. 1.

ance of A B *hot* from the effect of a current, the magnitude of which is shown by the ampere-meter, would now be known. This was practically the case. The quantity of oil surrounding the German silver wire was so considerable that the temperature rose but little, and the change of resistance of German silver with temperature is so small that it was unnecessary to apply any correction. It would be easy to keep the temperature of the oil quite constant by occasionally passing a test tube containing a little ice or a small freezing mixture from place to place through it, and then stirring the whole up thoroughly.

The resistance of the copper wire first *cold* and afterwards *hot* having been determined, and the temperature of the wire

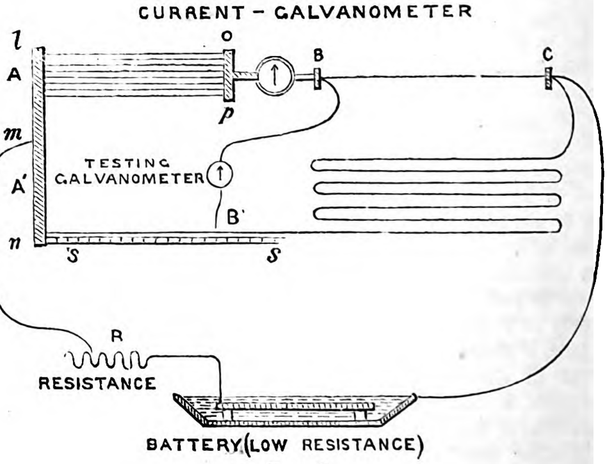

FIG. 2.

when cold being known (as at the beginning the temperature of the wire was the same as that of the air), it was easy to find the temperature of the wire hot by applying the formula for temperature correction for the resistance of copper.

I have also used latterly for passing a powerful current through a wire under experiment, and for determining the resistance of the wire while the current is flowing, a Wheatstone bridge, suitably arranged for the purpose, in accordance with a plan suggested by Sir William Thomson, and I find this method more sensitive and more generally convenient than the potential method.

The diagram (Fig. 2) explains the arrangement. A B C and A' B' C are the two branches of the Wheatstone bridge, and

* On the Permanent Temperature of Conductors through which an Electric Current is passing, and on Surface Conductivity, or Emissivity. By J. T. Bottomley. With a Note by Sir William Thomson, F.R.S.

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the four conductors are made up as follows: B C is the wire under experiment as to heating by the current; *l m n* and *o p* are two bars of very stout copper, and between *o p* and the portion *l m* of the bar *l m n* there are soldered a considerable number of stout copper wires making up a compound conductor of small resistance, and having very large surface exposed to the air for cooling. Between *o p* and B a current galvanometer of very small resistance is introduced for measuring the whole current flowing in the branch A B C, and therefore through the experimental wire B C. The branch A′ B′ C is a single long wire having many times the resistance of the branch A B C, and many times the resistance of the battery used, and thus only a small portion of the current passes through it—a quantity, in fact, unable to heat this branch to any appreciable extent. The testing galvanometer is introduced between B and B′, the contact at B′ being shifted about till a "balance" is obtained; and from the position of B′ on the scale *s s* the ratio can be calculated between A′ B′ and B′ C, when the equipotential point has thus been found.

In experimenting, the wire B C is soldered between stout copper slips for the purpose, shown in the diagram at its extremities, and its resistance is taken with a very small current passing through it, the resistance R being provided for the purpose of varying the current. The current is then increased by diminishing the resistance R. When this is done, the wire B C becomes heated, and its resistance increases, but the conductor A B and the branch A′ B′ C remain unaltered, though the ratio between the parts of the latter corresponding to the "balance" is changed.

Let c be the resistance of the conductor A B; let r_1 and r_2 be the resistances of B C when respectively the weak current and the stronger current are applied; also let a_1 a_2 and b_1 b_2 be the corresponding respective lengths of the shorter and longer parts of the branch A′ B′ C,

Then

(1) $$c : r_1 :: a_1 : b_1$$

and (2) $$c : r_2 :: a_2 : b_2$$

Hence $$\frac{r_2}{r_1} = \frac{a_1 b_2}{a_2 b_1}$$

Let t be the temperature of the air of the room where the experiment is made, and let it be assumed that the temperature of the wire B C is the same as that of the air during the first experiment with the weak current; let θ be the temperature of the wire when the stronger current is passing. Let σ_t and σ_θ be the specific resistance of these substances at these temperatures.

Then, $$\frac{r_2}{r_1} = \frac{\sigma_\theta}{\sigma}$$

the change in dimensions of the wire due to heating being left out of account. The values of σ_t and σ_θ can be found, as has been remarked already, for copper and for several other substances from well known tables and experiments.

My first experiments, after some preliminary trials had been made, were on a series of copper wires, all of them cut from the same piece, and of the same length, but some of them bare and others covered with different insulating coatings. The wires were about No. 21 of the old B.W.G., 0·81 millim. in diameter and half a metre in length. The resistance of each, with only as much current passing as sufficed for the ordinary application of Wheatstone's bridge, was 0·0183 B.A. unit. These were tested by the potential method described above. Eight wires were taken, and their surfaces were prepared as follows:—

A. Surface amalgamated with tin and mercury.
B. Surface amalgamated with mercury by rubbing on mercury nitrate and washing.
C. Bare surface (dim).
D. Covered with cotton and shellac.
E. Cotton-covered.
F. Shellac varnish.
G. Bare, polished with fine emery.
H. Thick coating of lampblack.

These wires were tested successively with currents of 1·2 ampere, 3 amperes, 5 amperes from the battery; then with 10 amperes, 20 amperes, and about 30 amperes from the dynamo-electric machine, the last named current overheating both the coverings and the wires and burning some of them up. The differences of temperature were wonderfully small, but they were decided. The following table shows the wires arranged in order of coolness, and therefore of the efficiency for emission of heat of their respective coverings:—

Current—								
1·2 ampere	H	D	C	E	F	G	B	A
3 "	H	D	C	E	F	G	B	A
5 "	H	D	C	E	F	G	A	B
5 "	H	D	C	E	F	G	A	B
10 "	H	D	E	C	F	B	G	A
20 "	D*	F	H	E	C	G	B	A

With about thirty amperes—

Tin and mercury ...	A	Surface slightly fused and blistered.
Mercury	B	Wire totally dissipated.
Bare surface (dim)...	C	No visible alteration.
Cotton and shellac...	D	Coatings fused together.
Cotton covering ...	E	Covering burned off.
Shellac varnish	F	Covering fused.
Bare polished	G	No visible alteration.
Lampblack	H	No visible alteration.

It appears, therefore, that the surfaces stand as follows in order of cooling efficiency:—

H, lampblack.
D, cotton and shellac.
C, bare wire, dim—in common unaltered condition.
E, cotton covered.
F, shellac varnish.
G, polished copper.
B, mercury surface.
A, tin and mercury.

In order to show a comparison as to the amount of cooling effect, I may here quote the temperatures of these wires with a current of 5 amperes passing, and in air at 11° C. This was the highest current I was able to apply with the battery I then had at command, and with the mode of experimenting which I was using at the time these experiments were made. The temperatures were determined in all the cases mentioned in the table above, but with the higher currents there was in this series of experiments some uncertainty owing to the fluctuations of the potential of the dynamo-electric machine; and, moreover, it is the less necessary for me to quote these here as I hope shortly to make the whole investigation more thorough and more satisfactory.

Temperature of wires with 5 amperes passing, the temperature of the air being 11° C.—

A	Tin and mercury............	22·5°
B	Mercury	22·5
C	Bare wire (dim)	21·75
D	Cotton and shellac	21·5
E	Cotton-covered	21·75
F	Shellac varnish	21·8
G	Polished copper	22·0
H	Lampblack coating.........	21·0

The numbers in this table show that the permanent temperatures assumed in the various cases differ wonderfully little with so great differences as to clothing; and that, at the least, there is no tendency in the covered wires to attain a temperature higher than that taken by the uncovered wires. With stronger currents it is made much more apparent that the covering does, on the contrary, favour loss of heat by emission at the sides with a wire of the size here referred to.

The following table contains the results of experiments on five copper wires of good conductivity with various coatings. In the first five columns are given particulars regarding the

* Covering probably half burned in D and F. The wires bracketed were equally heated.

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wires and the current passing through them. The sixth column shows the difference $t - \theta$ between the temperature assumed by the wire and that of the surrounding air, the latter being in all these cases about 12° C. In the seventh column is given the emissivity of the outer surface, or the quantity of heat (C.-G.-S. units) lost by the surface per second per square centimetre of cooling surface per degree centigrade of difference of temperature of cooling surface and surroundings.

Specifying number B.W.G. and nature of covering.	Length of wire. Centims.	Resist. of 100 centims. B.A. units.	Diameter of wire in millims.	Dia. of covered wire, outside.	Current (amp.).	$t - \theta$	Emissivity.
						deg.	
No. 22, silk covered.	100	·0395	·76	·96	10	23·4	0·001333
No. 26, cotton covered	100	·094	·50	·88	10	58	0·001385
No. 26, silk covered.	100	·1115	·45	·57	9·8	70	0·002020
No. 22, gutta percha	100	·0455	·72	1·67	10	24	0·000854
No. 22, tinned, gutta percha covered and double cotton covered outside	100	·0432	·73	1·86	10	23	0·000759

I may next refer to experiments on a length of wire which was first tested in its ordinary state, then when highly polished, and afterwards with the surface covered with coatings of shellac varnish thickly put on and gradually increasing.

Here I had—

Length of copper wire	50 centims.
Diameter	0·97 millim.
Resistance with feeble current	·01268 B.A.U.
„ „ German silver wire	·020
Ratio.....................	·634

With current of 10 amperes I found—

Condition of surface.	Ratio of copper to G.S.
Bare unpolished....................................	·6635
Bare highly polished	·6534
One coating shellac	·6547
Two „ „	·6510
Three „ „	·6466
Three „ „ and a covering of cotton wool after three minutes	·6595
Ditto six minutes	·6668
Ditto nine „	·6325

Another wire was similarly treated with coatings of Brunswick black and thin tissue paper, and gave the following results :—

	Ratio of copper to G.S.
Bare wire	·9895
One coating Brunswick black	·9745
One B.B. 5-ply fine paper	·9833
One B.B. 5 paper 1 B.B.	·9844
One B.B. 5 paper 2 B.B.	·9853
Same with 20-ply paper added...................	·9982

The current was in every case 10 amperes. Increase in the numbers indicates increase in the resistance of the tested wire, and therefore increased temperature; while decrease in the numbers quoted shows decrease in the temperature. The change in the permanent temperature is not more than two degrees; and the result of these experiments may be briefly stated to be this, that there was exceedingly little effect in the way of keeping up the temperature of a No. 20 B.W.G. copper wire, about 1 millim. in diameter, by covering it up with paper and Brunswick black till it attains an external diameter of more than a centimetre and a half.

A large number of experiments were tried of a kind similar to the one just quoted, and all of them giving similar results for wires of similar dimensions. I propose with improved arrangements which I have now at command, to obtain numbers which shall be more accurate than those which I have yet obtained; and to extend the experiments to the case of wires of larger diameters.

(TO BE CONTINUED.)

SUBMARINE CABLES IN WAR TIME.

Sir James Anderson writes as follows to the *Pall Mall Gazette* of Oct. 22 :—

"In the *Pall Mall Gazette* of October 17, 'One Who Knows' says, in paragraph 1, after the heading 'What should be Done'—

"'A telegraphic cable should be laid down connecting West Africa and the Cape direct with England. All our telegraphic communication with South Africa passes through Suez, and would be intercepted in case of war. From the Cape cable communication should be established with India and Australia. A cable should also be laid to Bermuda. The telegraph stations where the cable touches ground should be placed within fortifications, and this of course applies equally to the English end of the cable.'

I am at one with him as to the necessity of arming our coaling stations and increasing our cruisers, but I consider his reasoning about telegraphic communication very wide of the mark. I have not a word to say against cables being laid anywhere if Governments care to subsidise them, but it is altogether misleading to assume that cables laid where proposed, or the fortification of the landing places, will give us any security whatever for uninterrupted telegraphic communication.

"There are only two ways of looking at this feature.

"There should be as many alternative lines of communication as possible, so as to make it not worth while for any enemy to cut cables. All cables can be cut at all depths out of sight of guns or land, but they cannot so easily be repaired, and those suggested would be more difficult to repair than any yet laid.

"Cables in time of war should be landed at certain well-defined points, and, where convenient, landed at certain harbours—these points and harbours, as far as possible, to be known only to the Government for their own use. Then, if at any port or point telegraphic communication is interrupted, a despatch vessel must go from one point to another until she finds communication uninjured.

"In my opinion there can be no other plan of making use of the telegraph at distant points where alternate land lines do not exist. Government should therefore favour telegraph cables being laid where possible, so as to touch at as many points as can be made convenient. Despatch vessels should have the means of lifting cables at any of the points arranged, and telegraphing on their own account. The cables suggested by 'One who Knows' favour this arrangement less than any others, unless the line proposed to be laid along the West Coast of Africa be made to touch at all the ports, and at other points to be agreed upon, by the nation giving the indispensable subsidy.

"But if English commerce is to be defended by the Cape route, in my opinion the telegraph will do little for it, and the commerce will be limited to fast steamers, defended by fast cruisers stationed or cruising between certain latitudes and longitudes. Our slow steamers and sailing ships must sail under another national flag or lay up in docks idle. It will be very strange if this should come about. It can only continue if Great Britain ceases to be a European Power; and before that takes place there has to be a great war and a supreme struggle. This will not depend upon any Government. The nation will demand the struggle at any cost and any sacrifice. This is not Jingoism.

"One cannot fail to observe that no matter who makes the shortest road, by canal or otherwise, and no matter who opens up a trade route, our countrymen go for it and use it. The Mediterranean is the shoutest route to India, China, and Australia, and we are not going to give it up until we are thrashed out of it—that is, until we can no longer call ourselves a European Power.

"Then there exist so many alternate European routes, so that if all the main cables were cut it is only a few hours to two days' sail for a despatch vessel to reach telegraphic communication through some neutral territory. In this case it would answer no useful purpose to cut cables, and if cut they could be repaired under the protection of our cruisers. To my judgment we shall have to fight for the right of way along this route, no matter what it costs, or cease to be a great Power, and so long as we cannot command that right of way we must depend mainly upon vessels sailing under a foreign flag for our food supplies.

"Cables laid in short sections, despatch vessels specially fitted, and ships with cable, to connect such points as may be desirable in the vicinity where war is imminent or in progress, are the only methods of providing for telegraph communication in time of war, where there exist no alternate lines in the hands of neutral powers.

"I cannot understand the hesitation in arming our coaling stations for defence. This has to my mind been always unaccountable, but I have a strong conviction that when danger really becomes evident to our public we will pull ourselves together, and give our neighbours a good deal of trouble before they push us off the European track to the Mediterranean, India, Australia, &c. It will be a poor day for our country and our commerce when we are driven on to the Atlantic for all our supplies and trade."

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ELWELL AND PARKER'S PATENT ENGINE.

This engine, although of the ordinary single acting type, presents some features of novelty, and its performances are said to be excellent.

The particular engine which is the subject of our illustrations has a 10in. cylinder, 9in. stroke, and is arranged to run at 500 revolutions per minute. This is by no means the highest speed at which they will run, but the company, wisely, do not recommend excessive velocities, as the difference in the power given on the brake and that shown on the diagram becomes so great, owing to the rapid increase of friction, as to seriously detract from the efficiency and economy of the engine.

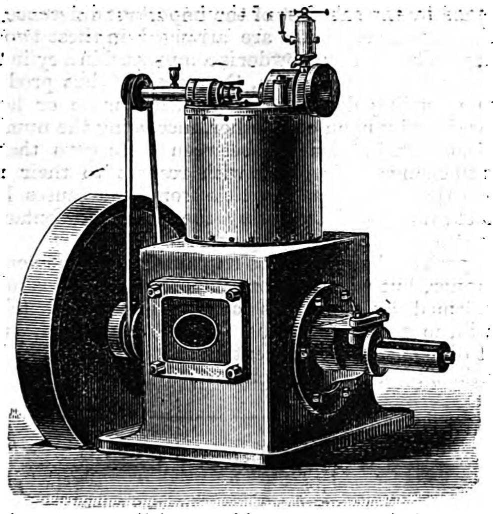

Fig. 1.

It will be seen on reference to the illustration that the engine differs from many of the same class, by the fact of its having only one cylinder, an arrangement which, without sacrificing the steady running, very greatly lessens the number of working parts, reducing the wear and tear to a minimum, and simplifying the whole machine. The cylinder is mounted on a base of box form, which encloses the working parts, and into which the exhaust steam passes. It is provided with circular facings on each side for the two side covers forming the main bearings, a square cover for access

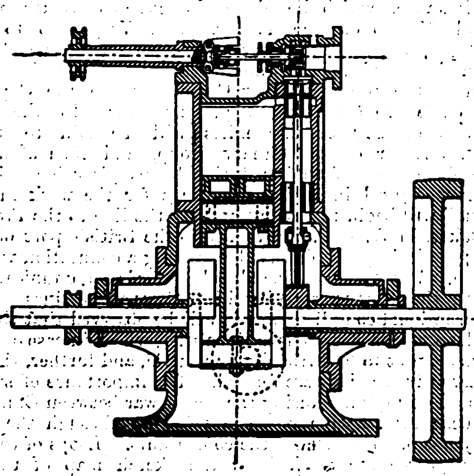

Fig. 2.

to the interior and the exhaust outlet. The position of the latter plays an important part in the working of the engine, as upon this the efficient lubrication depends. The exhaust steam condenses slightly as it passes through the base, and the water, with the oil floating on the top of it, accumulates and rises up to the level of the outlet. Before, however, it quite reaches this height the connecting rod end is arranged to dip into it at each stroke, which splashes the oil and water over the whole of the moving parts. The main bearings are of very ample length, and fitted with phosphor bronze bushes. A passage is cast in the cover above the bush, which catches the oil and water, and conducts it to the outer end of the bearing, from where it circulates back along the usual oil grooves into the base again. A small stuffing box and half round gland serve to prevent any leakage to the outside. The crank shaft is of forged steel, and the balance weights are dovetailed on and securely bolted.

The slide valve is of the piston type, of novel construction. It consists of three rings united to each other and to a central boss by webs, the central ring forming a diaphragm to divide the steam and exhaust ports, the other two forming guides which prevent the cutting of the edges of the ports. A valve of this character is found to work quite tight without any spring rings, and remain so after a large amount of usage. The passages are designed to allow a maximum speed of 5,000ft. per minute for the steam, the exhaust being enlarged as much as possible, and an auxiliary port formed at the lower end of the cylinder, to be uncovered by the piston in its travel. We have now before us diagrams taken from this engine at various speeds, showing a very good distribution of steam, which should go far to overcome the objection often raised against this class of engine on the score of economy. The governor is placed horizon-

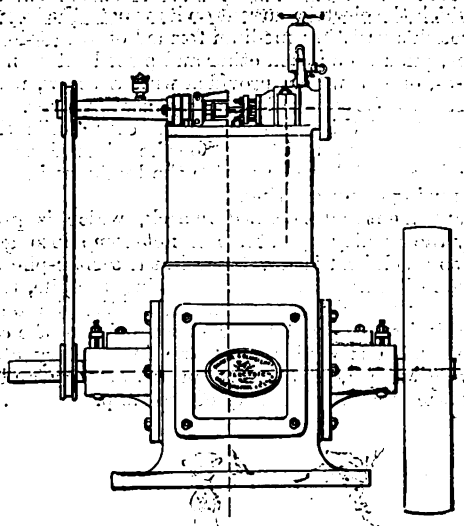

Fig. 3.

tally across the cylinder cover, operating an equilibrium valve in the steam-pipe, and is made extremely sensitive in its action by a very neat device, adjustable to any required speed. The driving shaft is carried by a phosphor bronze bush, bolted to the cover, at the outer end of which is the driving pulley. The lubricator which supplies oil to the whole of engine, with the exception of the governor spindle, stands on the steam-pipe.

Speaking generally of the engine we may say that the whole of the flanges and phosphor bronze bushes are bright, and fitted with

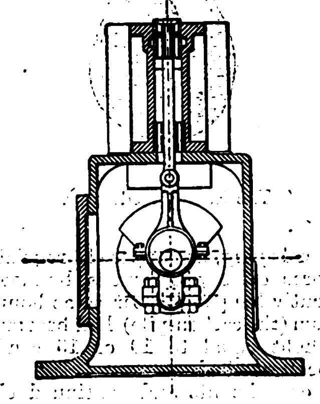

Fig. 4.

bright nuts, the flywheel is turned and polished, and the cylinder lagged with sheet steel, forming a very handsome and compact piece of workmanship. The castings are of the exceptionally clean and perfect character for which the company are so justly celebrated, and the workmanship is no less creditable.

These engines have up to the present been principally supplied to the inventors, Messrs. Elwell and Parker, of Wolverhampton, for use in conjunction with their well-known dynamos and accumulators, where they have been a great success, but we feel sure they only require to be known to engineers to ensure their being extensively applied not only for electrical purposes, but for all situations where a high and uniform velocity is required. We may mention, in conclusion, that the Coalbrookdale Company are now engaged in rearranging and adding to their engineering department, in which, when finished, they will be able to deal with work of the heaviest and highest class.

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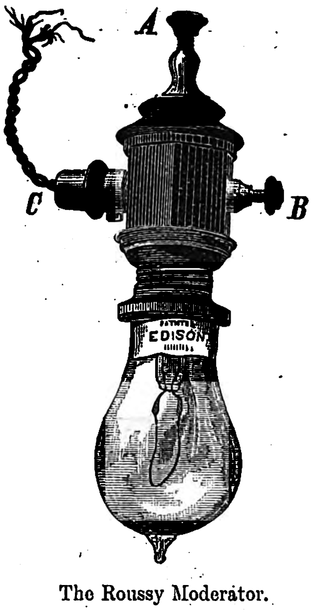
THE ROUSSY ELECTRIC LIGHT MODERATOR.

Since the application of incandescent electric lighting, many attempts have been made to invent an apparatus, simple and at the same time working with precision and safety, so as to regulate, according to requirements, the intensity of each individual lamp within the same circuit. It has not yet been found possible to practically apply the results of these trials, because the contrivances for that purpose, more or less satisfactory, are all very complicated, and cannot be easily inserted into the lamp-holders without causing inconvenience.

The apparatus most nearly fulfilling the desired object before the invention of the "Roussy" moderator was the "Stanley" regulator, by which the electric current on its way to the lamp was made to pass through a resisting medium formed of a certain number of carbon discs, piled up on each other and placed between two steady metallic discs, one of which, provided with a screw, permitted the carbon discs to be pressed one against another. According to the intensity of this compression the carbon-pile thus formed opposed more or less resistance to the electric current; and it was therefore possible to guarantee the luminous intensity of the lamp by screwing or unscrewing.

This arrangement had a great drawback, which is probably the reason why the Stanley regulator has not come into general use. In its use, so much heat is developed in the carbon-pile as to cause an expansion of each of the discs forming the pile, the height of which is thus increased; but, as the ends of the pile touch the two fixed metallic discs, an automatic compression of the carbon discs takes place, which is equivalent to an involuntary effect of the screw above described, and causes an involuntary and automatic increase of the luminous intensity of the lamp.



The Roussy Moderator.

For instance, after having, as supposed, regulated the intensity of a lamp to a force of, say, 8 candles, by means of the Stanley regulator, it frequently happened after some hours' lighting, when the resisting medium (the carbon-pile) had become heated, that the lamp produced a light equal to 10 or 16 candles without the regulator having been touched.

After numerous experiments and continued observations upon the circuit of Edison lamps at the Gilamont Mills, their owner, M. E. L. Roussy, who introduced incandescent electric lighting into Switzerland, succeeded, independently of Stanley's invention, in constructing a regulator, or, as he calls it, a *moderator*, also composed of a resisting carbon medium, but not open to the great objection described above.

The accompanying illustration shows a lampholder with the Roussy moderator, carrying an Edison lamp. A is the turn button of the moderator; B the interrupter; and C the aperture for introducing the wires. M. Roussy places inside the lampholder a small hollow cylinder made of glass or some other insulating substance, and filled with carbon powder. This powder is put in contact with one of the lamp poles in order that the electric current may pass through the carbon powder before reaching the lamp. Moreover a screw permits of the powder being more or less compressed in its cavity. If a strong compression be exerted upon the carbon powder it will form a compact conductor, allowing the current to pass to the lamp without hindrance. But if the compressing button be unscrewed, the electric current causes an automatic disaggregation of the compressed powder, and the more this becomes loosened the greater will be the resistance to the current, and the less brilliant will be the light of the lamp. What happens on such a resisting medium becoming heated? Numerous and protracted experiments have been made to clear up this question; and they have shown that the heated state of the powder in this regulator does not alter the intensity of the resisting property of the latter, while the mechanical compression of this same carbon powder will to a certain extent reduce the resistance it exerts against the current passing through it.

This result, although practically attained, seems contradictory, as it must be conceded that in the Roussy moderator, as well as in the Stanley regulator, the heating must necessarily be followed by an expansion of its elements. However, the difference in the results may be explained by the sole fact of the important difference in the form and in the manner elements are arranged in these two systems of regulating. When carbon powder is compressed in a cylindrical cavity by a screw acting like a piston, the pressure thus produced causes little or no settling down. The particles, more or less reduced, press more heavily upon each other, increasing the number of their points of contact, but leaving between them gaps that allow the particles to change their places with respect to their neighbours, when the expansion of each particle from heat causes lateral pressure, which, instead of increasing the points of contact, only produces a natural settling of the powder.

It will perhaps be possible to explain this phenomenon in some other manner, but what is most important is the result, obtained and confirmed by numerous carefully-conducted trials. These results will, moreover, soon be publicly confirmed, as M. Roussy intends to demonstrate his invention at the International Exhibition of Inventions to be held in London next year.

WEST AFRICAN CABLE.

The largest of the great steamships specially constructed for the purpose of laying ocean cables, the "Silvertown," a vessel of nearly 5,000 tons burden, sailed on Wednesday from the Thames with the second section of the telegraph cable by which it is proposed to connect the English settlements on the West Coast of Africa with this country and the Cape of Good Hope. In three capacious tanks, 55ft. in diameter and 30ft. deep, she bears, coiled in convenient lengths, about 1,200 miles of cable manufactured by her owners, the India Rubber, Gutta Percha, and Telegraph Works Company (Limited). Although this may seem a very long piece of one of these lines for telegraphic communication with which the earth is now girdled, the section on board the "Silvertown" forms barely more than half the load the ship is constructed to carry. In laying the cables, for instance, which lie along the coasts of South and Central America and Mexico on the Pacific, from Valparaiso to the Gulf of Tehuantepec, she took for one section of that line 2,370 miles of cable in her tanks. She now steams to Teneriffe, where the first section of the proposed West Coast route to the Cape Colony, the direct cable from Cadiz, at present ends. In the first place a short cable of 200 or 300 miles will be laid to the island of Lanzarot, another of the Canary group, and then after receiving information from the staff on board the Company's cable ship "International," now engaged in taking soundings for the work in hand, the "Silvertown" will begin to pay out and lay the line to the French settlement of Dakar, in Senegal, and thence to the British port of Bathurst. From this port it is probable that before long a connection will be made with St. Jago, whence a short line already affords communication at St. Vincent with the Eastern and Brazilian Companies' lines. In view of possible international complications, it will be observed that the projected route includes stations of various nationalities, which in case of a European war we might expect to find friendly or neutral, and further, that as far as possible, alternative sections are formed. The importance of such precautions has been exemplified during the recent war between Chili and Peru by the frequent interruption of communication through the cutting of the cable by one or the other of the combatants. Loops of the projected West African cable are marked on the sketch map of the route to join Bathurst with Bissao and Bulama, and independently to link Bathurst with Freetown (Sierra Leone) and Freetown with Accra. Whether the several forts and stations of the Gold Coast Colony shall be provided with telegraphic means of inter-communication or not the Government do not appear to have yet decided. The selection of the port or ports at which the cable shall touch in order to supply the wants of the Congo region also remains to be made. A guarantee of traffic has already been obtained from the Portuguese Government, and landing rights have been granted by the Government of the Cape, and the company is now in negotiation with the Home Government, with a view to obtain a subvention for stations at Sierra Leone, and on the Gold Coast. Among a party of visitors who were invited to inspect the works of the company at Silvertown, and were afterwards entertained at luncheon on the cable ship, were the Chargé d'Affaires at the Portuguese Embassy, Sir T. Scanlen, Mr. J. X. Merriman, M.L.A. of the Cape Colony; Sir Samuel Rowe, Governor of the Gold Coast; Sir Charles Tupper, Captain D'Almeida, Royal Portuguese Navy; Mr. Juland Danvers, Mr. Alfred Giles, M.P.; Count d'Oksza, and M. Laporte and M. L. Couzy, French Government engineers.—*The Times.*

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COMPANIES' MEETINGS & REPORTS.

West India and Panama Telegraph Company (Limited).

The fifteenth ordinary general meeting of this Company was held at the City Terminus Hotel, Cannon-street, on the 22nd inst., under the presidency of Mr. C. W. Earle.

The SECRETARY (Mr. R. T. Brown) having read the notice convening the meeting and the minutes of the last meeting, which were confirmed by the present meeting and signed by the Chairman as correct, the report of the Directors was taken as read.

The CHAIRMAN: The accounts for the half year show a falling off in the total gross receipts of £1,964. There is a reduction in the expenditure of £1,477, and the balance is smaller than it was in the corresponding period of last year by £487. But it must be remembered that we are comparing with a very prosperous time. Our receipts in the corresponding period of last year were £6,000 better than in the preceding corresponding half year, and they again were the best we had ever had. Therefore I do not think that on the present occasion we show any very great reduction in the traffic, notwithstanding the depression through which the West Indies are passing. It is also to be noted that there was a small item of £800 in the last year's accounts which was interest, and which does not appear this year, because the interest upon the reserves now being invested in interest-bearing stocks has been carried to the credit of reserves and figures in the balance sheet. If that amount had appeared where the similar credit appeared last year, it would convert the comparison into a small profit, not into a small loss. As to the expenditure side of the accounts, the reduction in the expenditure is attributable entirely to some exceptional charges which appeared in the corresponding accounts last year. There was an item of the expense of the missions to the West Indies, and some exceptional expenses were incurred on this side. This accounts for the comparison being in this half year's favour, because I do not think there is anything to be hoped in the way of reducing the expenditure of the Company. Every item is watched with the greatest care, and I do not see myself where any further saving is possible to be made. During the half year we have had as many as twelve interruptions to cables. Fortunately our system is almost entirely duplicated, so that most of those interruptions occasioned no loss to traffic. But there was a serious interruption to the British Guiana (Demerara) cable, which is not duplicated, and that affected our traffic for a time. There was also an interruption to the Barbadoes cable, which affected our cable for a very short time, and then the connecting cables between Florida and Havanna were simultaneously broken with the cables belonging to the International Ocean Company. That company employed our two ships to repair those two cables. It was very promptly done, but still for a time there was a certain delay—a delay, perhaps, of 20 hours in communicating with the West Indies. The progress we have made in repairing the original San Juan (Porto Rico) cable has been satisfactory. We have completed it up from Porto Rico to within 30 miles of Jamaica. The ship is now engaged in grappling for the end near Jamaica. While she was at work there the other day an intertuption occurred on the other Porto Rico cable. She therefore left the work she was on, and repaired this last mentioned interruption very promptly, and it was only five days interrupted. But at the same time a cyclone swept over the island of Jamaica, and blew away or washed away a great portion of the land line which connects the northern landing place to the town of Kingston, and consequently the Colon cable. The result of that was shown in the serious falling off in the last returns published in the papers —a falling off of 30 per cent. I am glad to say, however, that the traffic revenue of this half year is a little in excess of what it was in the corresponding half year, notwithstanding the serious falling off in the last fortnight. It is a great matter of satisfaction to us that we have been able to persuade the colonies of St. Lucia and Grenada to make the increase alluded to in the report in their subsidies to us. At a time like this, when every one is very much disheartened about the commercial affairs of the country, it is very generous of these two colonies to have given us this small increase. Just look back on what we found the state of this subsidy grant when we took office in 1874. The total nominal subsidies then were £1,680. They were very irregularly paid, however, because the lines were in a very unsatisfactory condition, and, in fact, I may say, so far as I know, that we did not get very much more than a few hundred pounds out of all these subsidies before 1874. Since then, however, the lines have been put in order, and the subsidies have been paid almost entirely. But we have been able to obtain from the colonies a total increase of those subsidies, amounting to £7,800, bringing up the nominal subsidy account payable to £24,600 instead of £16,800, which we found it. It is not a very easy thing to induce people to pay more than they have contracted to pay. There is a saying somewhere of Lord Salisbury, when he was called upon to make some foreign negotiations, to the effect that he did not like to go into the market without money in his pocket. We have always had to do that. I do not mean actual cash, but we have had nothing to offer the foreign colonies. We have been merely able to say "your subsidies are not anything like sufficient to give a fair return on the capital invested, and we beg you to increase them." Well, gentlemen, we have so far succeeded to the extent of obtaining an increase of £7,800 in that way. There are still the colonies of Barbadoes, and the group of the Leeward Islands, with the Island of St. Vincent, which adhere to their pound of flesh, and have not granted us any increase as yet. As to the foreign colonies I do not expect to receive very much consideration from them. In the first place, St. Thomas is in a very low financial condition, and perhaps it is as much as they can do to pay the £1,000 they pay us now. The subsidy expires at the end of this year, and we have applied for its renewal. The French colonies are in the same condition as to the expiration of their subsidies, and we have applied to them for their renewal, and we must wait to see what comes of the application. Unfortunately there is not a very favourable feeling between France and England now, and I should be deceiving you if I expressed myself in a very sanguine manner of getting very much more out of them than we have hitherto done. No doubt every one has noticed the amount of attention which the West India Colonies have received since last we met in this room. The commercial depression has been very striking. The price of sugar has fallen 50 per cent. Sugar we were importing two years ago at about £1 per cwt. has been down as low as 10s. 9d. on the 3rd of this month. You can easily see what a deplorable change that heavy fall must make in the great industry of the colonies which we serve, and although we have not as yet apparently suffered very much from it, we must expect that the want of prosperity on the part of those whose business we carry on must affect us more or less. I will only say that we feel very great sympathy with them at this extraordinary depression from which they are suffering. There have been many suggestions made as to remedying it. Countervailing duties, amalgamation with the United States of America, incorporation with Canada, and various other schemes have been suggested. But it is, of course, for the statesmen of this country to see whether there is any way out of the difficulty which threatens so seriously our West India possessions. There has also been a little stir about the defence of our colonies. There are two important ports in our West India region, the ports of Kingston, Jamaica, and also St. Lucia, both of which are important coaling stations, and may be more important when the Panama Canal is completed. Whether the attention of the Government will be turned to strengthening the defences of these places I do not know, but if it is one cannot conceive that telegraphic communication with those countries will not form a very large portion of the elements for consideration. We must wait and see what turns out, and all that we have to do is to try by the formation of sufficient though not extravagant reserves to keep up such a position that we can act in association with the Government in the best way to strengthen the colonies, and also if possible to improve the position of the long suffering shareholders of this Company. I now beg to move, "That the Directors' report and accounts to the 30th June, 1884, submitted to this meeting be and the same are hereby received and adopted, and that as recommended by the Board a payment of 6s. a share on account of arrears of dividend on the First Preference shares be and is hereby declared."

Mr. WILLIAM FORD seconded the motion.

Mr. CHAPLIN asked whether the Board considered it discreet to mention the amount to which they proposed to build up the reserve fund. Speaking as a debenture holder, he himself would be perfectly satisfied if it reached £100,000.

Mr. GRIFFITH said that the Chairman had stated that the land line to Kingston, Jamaica, had been interrupted, and that that interruption had caused a serious falling off in the income of the Company. He (Mr. Griffith) wished, therefore, to know whether the land line had been renewed.

The CHAIRMAN replied in the affirmative, adding that it was renewed in five days, and that they were now working at every station.

Mr. MORTON said he was a second preference holder, and he wished to know how long they were to wait for a dividend. The Company was now earning the full interest on the first and second preference shares, putting £20,000 to the reserve fund, and spending a large amount on the cables. There was a reserve fund of £80,000, and they had also a reserve of £9,000 for depreciation of ships. The total arrears of dividend now on the first and second preference shares was £64,000, so that there was really in hand not only the whole of the money to pay off all the arrears of the preference dividend, but also a considerable reserve, which might be built up every year. He would not object to forego his dividend for another year, but he could not gather from the remarks of the Chairman any hope that the second preference shareholders would be paid at all. He did not say that the Directors did not earn their fees, but he certainly objected to their receiving £2,000 a year when he received nothing. There was really £100,000 in hand which belonged to the shareholders, and he maintained that the Directors had no right to add to the reserve fund and so keep the shareholders out of their dividend. He would not move any amendment to the report on the present occasion, but next half year, if they were not treated with proper fairness, he would move an amendment with the view of their obtaining fair treatment.

The CHAIRMAN: It is just a year since that Mr. Morton brought up this same subject—the subject of the reserve fund—and Mr. Chaplin asked a question as to what extent the reserve fund was to be built up. I am not prepared to say when we shall cease adding to the reserve fund. There must always be a gradual contribution towards it. You must remember that our reserve fund is a very small one—very much smaller than that of any other submarine telegraph company in existence. When you recollect that the cables and the establishment of the Company cost £1,272,000, it is not very much to have in hand £90,000 or £100,000 to replace this wasting plant, which is depreciating every year at a certain unknown rate. I should be sorry to encourage any hope that this reserve fund is to be divided among the preference shareholders, for we depend upon it for our security, and it is that on which the ordinary shareholders rely for the reversion of their property. To divide it, therefore, would be most improper. The question of Directors' fees has been threshed out so often in this room that one would have thought that it would not be brought up again. The Directors were invited to come and manage your affairs. You never had one shilling of dividend before we came. We have done our best for you. You can dismiss us, but as long as we are here you must expect to pay us for our work. You might just as well expect to have your offices for nothing or to get the services of the staff for nothing as to expect the Directors to work for you without re-

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muneration. Nothing would give us greater pleasure than to be able to pay off all those arrears, and all we can do is done by us. We found this a most deplorable undertaking, not earning a halfpenny, and a bad field chosen, with which we had nothing to do, and it has been a work of extreme labour to bring about the comparatively small success which we have been able to obtain. I do not see that there is any argument or reason for taking the small reserve fund that we have and paying it away. The whole property might collapse, and no one would have a shilling by it if we found a necessity to use that reserve fund and we had not got it.

Mr. Morton: You have £9,000 reserve for the ships.

The Chairman: The ships are depreciated. They are eight or nine years old. They were not as good on the 1st of January this year as they were on the 1st of January last year. There is a certain depreciation going on which every business man must know has to be provided for. The cables are thirteen years old, and we have £100,000 to replace what cost us one and a quarter millions.

Mr. Morton maintained that justice ought to be done to the shareholders.

The Chairman: Justice is only what you can justly get. You cannot get blood out of a stone.

Mr. Morton: But the money is there.

The Chairman: Yes, but for the repairing of the plant which is depreciated.

Mr. Morton: Well, I have given you notice of what I shall do.

Mr. Robinson Kendal though that the speech which Mr. Morton had delivered showed what a dangerous thing a little knowledge was. Mr. Morton would lay his fingers on the £90,000 reserve fund and divide it among the preference shareholders, but if they looked at the balance-sheet they would see that there was no such sum as £90,000 to divide. The Company had a debenture debt of £50,000, and surely that debenture debt was a first claim on the Company. If they deducted that amount from the reserve fund there would be only £40,000 left, which was little enough. He would not enter into a discussion with Mr. Morton as to whether the Directors deserved their fees, but he would say that the accounts showed that the Directors had given the most valuable attention to the affairs of the Company, and whether the shareholders thought of the increase in the subsidies which the Directors obtained, or of the general management of the Company, or the manner in which the reserve fund had been created and invested, it was his opinion that the Board were entitled to the best thanks of the shareholders. As the Chairman had said the Company had very poor ground to work on. Moreover, trade had been restricted and almost paralysed by reason of the great depreciation in the sugar market. When they took into account the commercial position of the islands served by the Company, and the almost destitute condition that some of them were in, the Directors were not to be blamed for the want of increase in the revenue of the Company. He believed that the Board had done their best, and that, if there was any fault to be found, they could not be held responsible. The Directors were, on the contrary, to be praised for the manner in which they had conducted the Company and built up the reserve fund, without which the undertaking would have been in a very weak condition.

Mr. Morton maintained that it was absurd to contend, as the last speaker had done, that the arrears should not be paid off.

The Chairman put the motion and declared it carried unanimously, which concluded the business before the meeting.

The Telephone Company of Ireland.

The fourth ordinary meeting of this Company was held at Dublin on Friday, 17th inst., Mr. James Winstanley, one of the Directors, occupying the chair. A letter was read from Mr. Dwyer Gray, Chairman of the Company, regretting absence through ill-health, but congratulating the shareholders on their prospects, original shareholders receiving interest at the rate of 8 per cent., with reasonable prospect of increase. He added that no real points of difference remained between the Company and the Post Office Department, and he was assured the new license would be granted in a few days. The Chairman of the meeting, in moving the adoption of the report, said that the Company had, at considerable expense, erected poles and wires to Kingstown in anticipation of obtaining a considerable number of customers there. At that moment the circuit to Kingstown was complete; and gentlemen wishing to speak round that circuit, which was 15 miles in extent, could do so after the meeting was over. It was not yet fixed where the exchange was to be; but at present anyone in Kingstown requiring a private wire could have it. They were not prepared, however, to deal with exchange customers until they had their license. As soon as that was obtained, a scale of prices would be fixed which he was sure would prove satisfactory to customers in Kingstown. The report declared the dividends of 5 and 6 per cent. to the preference shareholders, a few of the 6 per cent. shares remaining unconverted.

Mr. Joseph Bond Morgan, representative of the United Telephone Company, London, said he had great pleasure in seconding the motion. He regretted that Mr. Gray, who had worked indefatigably for the development of the Telephone Company in Ireland, and also for the promotion of telephone interests in Great Britain, had not been there to say what he had so tersely written. Under the new license he did not see why they should not be able to talk to all the towns of England, while the English towns would be in communication with each other. The other day he spoke by telephone from Liverpool to London. Experiments had taken place between Liverpool, Manchester, and Bolton, round circuits of from 300 to 500 miles; and in the North the trunk lines between Glasgow and Edinburgh were being developed and extended. A line to Brighton was also under consideration, and it was even said that with sufficient insulation they would eventually be able to talk round the world, which was no doubt scientifically true. He was sure the future of the telephone was so vast that each year they would be more and more surprised by the progress made. That Company had never been in a better position than it was at present. With regard to patent rights, they had fought and won. They held patents of all the telephones that would be of practical use, which was a source of great encouragement to them and would also be a source of immense profit.

The report was adopted unanimously, as was a vote of thanks to the Chairman, who, in acknowledging it, said that the Company had plenty of scope and plenty of money, so that they had nothing to do but to work in order to ensure success.

The Brazilian Submarine Telegraph Company.

The report and accounts of the Directors for the half year ended June 30, 1884, to be presented to the twenty-second ordinary general meeting, October 31, 1884:—The revenue for this period amounted to £76,794 17s. 6d., and the working expenses to £12,868 17s. 8d. After providing £838 14s. 9d. for income tax, there remains a balance of £63,087 5s. 1d.; to this is added £243 17s. 3d., brought forward from 31st December last, making a total of £63,331 2s. 4d. A quarterly interim dividend amounting to £19,500 has been paid, and £24,000 transferred to the reserve fund, leaving a balance of £19,831 2s. 4d. The Directors now recommend the declaration of a final dividend of 3s. per share, making a total payment of 6 per cent. for the year ended 30th June, 1884, and that the balance £331 2s. 4d. be carried forward to the next account. The duplication of the Company's entire system of cables between Lisbon and Pernambuco has been successfully completed at a total cost of £650,922 18s. 6d., of which £500,922 18s. 6d. has been taken from the reserve fund; and the balance, £150,000, has been provided by the issue of the Company's Five per Cent. Debentures for that sum. Since the last meeting, the 1874 cable between Madeira and St. Vincent has been interrupted at two points, one near the Canary Islands, and the other close to St. Vincent. The cable was repaired thirty-two days afterwards, but the interruption resulted in no inconvenience, as the second cable was laid and working, thus preventing a serious loss of revenue to the Company. The cable, which has been submerged ten years, was found in excellent condition both as regards the iron sheathing and the core. All the Company's cables are now in good working order. Two of the Directors, Sir Thomas Fairbairn and Mr. Henry Daniel Gooch, retire by rotation at this meeting, and, being eligible for re-election, offer themselves accordingly. The two auditors, Mr. Henry Dever and Mr. John Gane, also offer themselves for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Oct. 22.		Business Done Week Ending Oct. 22. Highest.	Lowest.
Anglo-American	30½,	31½	32	30¾ x d.
Do. Preferred	53½,	54½	56	53¼ x d.
Do. Deferred	6½,	7	7	6¾
Brazilian Submarine	11¼,	11½	11 5-16	11½
Cuba	11,	11½	11½	—
Do. Preference	17,	18	17¼	—
Direct Spanish	3½,	4	—	—
Do. Preference	14¾,	15¼	15	14¾ x d.
Direct United States Cable	10,	10½	10¼	9 13-16
Eastern Telegraph	11⅝,	11⅝	11 11-16	11⅝ x d.
Do. 6 per Cent. Preference	13½,	13¾	13¾	13½ x d.
Do. 5 per Cent. Debentures, 1899	104,	107	—	—
Eastern Extension	11¾,	12	12 1-16	11¾ x d. & bonus
German Union	9¾,	10¼	10	9 15-16
Globe Telegraph and Trust	6¾,	7⅛	7⅛	7 x d.
Do. Preference	12⅜,	12⅝	12 11-16	12 7-16 x d.
Great Northern	13½,	13¾	13¾	13 11-16
Indo-European	32,	33	—	—
Reuter's	7½,	8	7¾	— x d.
Submarine	178,	183	182	178
West India and Panama	⅞,	1⅛	1	15-16
Do. 1st Preference	7¾,	8¼	7 15-16	7⅞
Western Brazilian	6¾,	7	6¾	—
Western Union 7 per Cent. 1st Mortgage	123,	125	—	—
Do. 6 per Cent. Sterling Bonds	100,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	5-16,	7-16	—	—
Oriental	⅛,	⅜	—	—
United Telephone	12½,	13	13½	12⅝

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1½,	1¾	1 11-16	1 9-16
Do. (fully paid)	2¾,	3¼	2⅝	—
Hammond Light (£3 15s. paid)	⅛,	⅜	—	—
Swan	—	—	—	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	34,	35	34¾	34¼
India Rubber, Gutta Percha, and Telegraph Works	22,	23	22¾	22¼

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NOTES.

BOOK RECEIVED—"Die Elektrische Beleuchtung," by Dr. Ernest Hagen.

TELEPHONY.—The trunk line between London and Brighton is, we understand, almost completed.

ELECTRIC LIGHT AT EASTBOURNE.—The Swan incandescent electric light has been introduced in to the library of the Grand Hotel at Eastbourne.

LECTURES ON ELECTRICITY.—Professor Tyndall's "Lectures on Electricity," translated by Joseph von Rosthom, have been published at Vienna.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 24th October amounted to £3,454.

ELECTRIC LIGHT IN MEXICO.—It is reported that the darkness which now prevails at the town of Chihuahua, in Mexico, is about to be dispelled by some form of the electric light.

ROCHESTER, N.Y.—The Citizens' Committee have reported in favour of lighting by electricity, and the Brush Company has offered to furnish 800 lamps at 90 dollars per light per annum.

THE CHINESE TORPEDO SERVICE.—In reference to the note in our last issue, a letter has appeared in the *Morning Post* stating that Mr. Betts was not in the employ of the Silvertown Company.

ELECTRIC LIGHT ON STEAMSHIPS.—A paper on this subject, by Prof. A. Jamieson, Principal of the Glasgow Science College, is to be read at the Institute of Civil Engineers on November 11.

EASTERN TELEGRAPH COMPANY.—The Eastern Telegraph Company announce the payment this day (Saturday) of interest for the half year ending 31st ult., on their 4 per cent. mortgage debenture stock.

ELECTRIC LIGHT AT HARROGATE.—The six arc lights, fixed in the Market Hall, Station-square, James-street and Parliament-street, were started last week, and are reported to give a very steady light.

ELECTRIC LIGHT AT LINLITHGOW.—A proposal has been made to light this town by electricity; and negotiations are going on with the electric lighting companies, with a view to ascertain the first cost and expense of maintenance.

ELECTRIC LIGHT AT VIENNA.—It is said that the Vienna Municipality wishes to adopt the electric light at the new Rath-haus, but that the conditions are so hard that they prevent any electrician from going in for the installation.

LECTURES.—Mr. E. J. Bruce is announced to give a popular lecture on Electric Light and Energy at the Kensington Assembly Rooms on Tuesday, 11th November. This lecture forms one of a series to be given in the metropolis during the winter months.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 24th October, were £2,724, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

SOUTH SHIELDS.—Mr. Eltringham, boiler maker, has just lighted his works by means of 12 Brush arc lamps, driving the dynamo from his shop engine. The work has been carried out by the Hammond Company, and the installation gives complete satisfaction.

WEST INDIA AND PANAMA COMPANY.—The repairs to this company's original cable between Jamaica and Porto Rico were completed on the 24th inst. By the re-establishment of this cable the duplicated telegraphic system of the West Indies is now in working order from Jamaica to Trinidad.

THE TELEPHONE IN BELGIUM.—While inaugurating the long-distance telephony on the Van Rysselberghe system between Brussels and Antwerp, the Belgian Government and the Bell Telephone Company agreed to take every precaution for maintaining the privacy of telephonic messages.

NATIONAL TELEPHONE COMPANY.—We have received the tenth issue of the list of subscribers to the Aberdeen district exchange of this company, corrected to October, and capitally got up. Besides the numerical list, there is an alphabetical and also a classified list, which greatly facilitate reference.

SIXPENNY TELEGRAMS.—On Friday, in reply to Mr. Ruston, the Postmaster-General said there was no intention to alter the decision announced by the Chancellor of the Exchequer when introducing his Budget, that the reduced rate for inland telegrams would be brought into operation on the 1st of August next.

ELECTRIC LIGHT AT HAVANA.—We hear that a few sugar houses and plantations in the island of Cuba are lighted electrically by means of Edison dynamos and Armington and Sims engines, for the ordinary motive power of sugar boileries cannot be relied upon for driving electric machines with sufficient regularity.

GAULARD AND GIBBS.—These inventors have written a long letter to the *Bulletin des Téléphones*, maintaining the correctness of the statement that, in the recent experiments between Turin and Lanzo, their secondary batteries yielded 89 per cent., and stating that this was verified by the International Jury of the Turin Exhibition.

ELECTRIC LIGHT AT CREIL.—The works of MM. Essaude Frères, at Nogent-les-Vierges, near Creil, are now lighted by six Jablochkoff candles, maintained by a self-exciting alternate-current Gramme dynamo. This has nothing to do with the plant being put down at Creil for generating current to be transmitted to Paris.

"ELECTRIC LIGHTING."—Under this title, Messrs. A. R. Sennett and Co., of Hatton-garden, E.C., have issued a pamphlet with some practical observations on electro-lighting, energy and power, the arc and incandescent systems, generators and accumulators, followed by approximate estimates for incandescent lighting and prices of their specialities.

THE POST OFFICE AND THE TELEPHONE COMPANIES.—In the House of Commons, on Thursday evening, Mr. Kenny asked the Postmaster-General if it was a fact that a proposition had been made to Government to buy up the interests of the United Telephone Company and its affiliated companies, at the sum of £2,000,000.—Mr. Fawcett said no such suggestion had been made.

CHELSEA.—We have frequently referred to the work of Mr. J. H. Stayton, in Chelsea, and regret to have to notice that he has been compelled to resign his position as engineer and surveyor to the vestry, owing to ill health. A number of Mr. Stayton's friends have presented him with a testimonial, to

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show their appreciation of his labours at Chelsea during the nine and a half years he was in office.

BLACKPOOL AND ELECTRIC TRAMWAYS.—The General Purposes Committee of the Blackpool Town Council, resolved on Thursday, October 25, to recommend electricity as the motive power for the new tramways about to be laid the full length of the Blackpool promenade. These electric tramcars are intended to surpass anything yet attempted in that direction, and may be expected to begin running early next season.

TELEGRAPH CHARGES IN SOUTH AUSTRALIA.—The Superintendent of Telegraphs states that "in future cipher rate is only to be charged in the case of artificially constructed words or groups of figures, a group of five letters or figures counting as one word, but one such group making the whole message chargeable with cipher rate. Proper names or plain dictionary words, whether they have a connective meaning or not, are to be accepted at ordinary rates."

ELECTRIC LIGHT IN THE CITY.—At a meeting of the commissioners of sewers, held recently in the Guildhall, Mr. Altman, the chairman of the streets committee, replying to Mr. Deputy F. Cox stated that that committee had before them an application for electric lighting, which, with modifications, they were likely to accept. He saw no reason why the greater part of London should not be illuminated by the electric light, an announcement which was received with marks of manifest approbation.

NEW THERMO-ELECTRIC BATTERY.—Professor Riatti has devised a new battery, based on the production of electric current through the difference of temperature of two states of one and the same substance. Two copper pipes, fixed a slight distance apart, pass through the wooden or porcelain cell, containing a solution of sulphate of copper, and are traversed, the upper one by steam and the lower one by cold water. When the circuit is closed, the copper of one pipe becomes dissolved and deposited on the other.

ELECTRIC LIGHT AT THE LAW COURTS.—Of course the *Journal of Gas Lighting* chuckles over the absence of the electric light at the Law Courts on the first day of term; but our contemporary ignores the fact that the delay is totally unconnected with the electric plant, as explained in our note last week. Several of our contemporaries complain of the insufficiency of the temporary means adopted for illumination; but the electric light will only be the more highly appreciated when the erection of the motors enable it to shine forth.

THE JOHN PENDER GOLD MEDAL.—This medal, which was offered by Mr. Pender, M.P., for competition to the electrical engineering students of the Glasgow College of Science and Arts last session, has been gained by Mr. D. S. Sinclair, originally from Caithness-shire. The medal, which was designed by the Principal, and executed by Messrs. Smith and Son, jewellers, Queen-street, Glasgow, is so far novel in shape. It consists of a watch guard pendant, containing a delicate compass card, while the frame, side, and back are of solid gold.

MAGNETIC HAMMERS.—Hammers, the heads of which are magnetised so as to attract nails, for facilitating the making of rough boxes for packing fruit, are now used on the Continent. We remember using magnetised tack hammers, so long as twenty-five years ago; but, although the heads were protected by a piece of india-rubber tube, they soon lost their magnetism. Certainly, we omitted to place them at night due north and south, parallel with the main direction of the earth's magnetism, which is perhaps the reason of their failure.

INSULATION OF CONDUCTORS.—Herr Justin Malisz, chief of the telegraph department on the Galician Railway, remedies the induction from telegraph wires passing through walls, due to the condensation of vapour in the ordinary porcelain tubes, in the following manner:—He forms the insulating covering of three porcelain tubes, slightly inclined outwards, surrounded by cement, and jointed with Jew's pitch dissolved in pure turpentine, the last tube terminating in a bell on which the water of condensation drips both inside and outside.

ELECTRIC LIGHT AT GENEVA.—A central station for electric lighting has been opened at Geneva, with an Edison dynamo, driven by an Escher-Wyes turbine, and capable of maintaining about seventy 16-candle lamps. The main cables are hung on posts for a certain distance and then fixed to the walls of houses. The illumination is at present confined to the Grand Quai and a few shops and cafés; but fresh applications are constantly being made, which will necessitate the laying down of additional plant, for which municipal authorisation is required.

ELECTRIC LIGHTING OF THE BONN STATION.—This station, which is to be opened on 1st April next, will be mainly illuminated by electric light, so arranged as to avoid simultaneous extinction. Three Siemens dynamos will generate current for as many separate circuits; while a fourth dynamo, driven by a special motor, will be held in reserve to guard against unforeseen breakdowns. The exterior, entrance hall, and waiting rooms will be lighted each with a Siemens differential arc light; and the offices, &c., by 80 Edison incandescent lamps. Provision for gas will only be made in the subsidiary departments.

ELECTRICITY AT THE ANTWERP EXHIBITION.—Independently of the question of electrically lighting the interior, referred to in another note, we learn that there is to be a special committee for electric experiments at the exhibition, and that the international committee on electricity will be divided into four sub-committees with the following functions: 1. Dynamical experiments; 2. apparatus producing or requiring intense currents, including dynamos, primary batteries and accumulators; 3. conductors and means for carrying them; and 4. apparatus for producing or requiring weak currents, such as those for telegraphs and telephones.

THE TELEPHONE IN ITALY.—On 1st October the General Telephone Company of Italy absorbed its last competitor in Rome, the Roman Telephone Company; and the new Società Romana dei Telefoni ed Electricità now works the Eternal City with 1,700 subscribers. With the increased accommodation, the subscriptions have been raised to 180 *lire* (£7 4s.) for the city proper, and 300 *lire* (£12) for the suburbs within three kilometres (nearly two miles); while, beyond this distance, an extra charge of 50 *lire* (£2) is made for every kilometre, or 1,093 yards. Subscribers who use a second receiving instrument pay an additional 6 *lire* (5s.) yearly.

STENOGRAPHIC TELEGRAPHY.—We learn from *Kosmos* that an Italian inventor has constructed an appliance for telegraphing stenographic signs. The transmitter consists of two series of ten keys, each of which corresponds with a special sound, and each sending a current to the receiver, as in the Morse instrument. The receiving apparatus consists of a combination of 20 Morse receivers, provided with a style, which traces its special mark on the paper, and thus reproduces the stenographic sign. It is stated that this new instrument is capable of transmitting 10,000 words in an hour, as against 500 by the Morse instrument, 1,200 by the Hughes, and 1,800 by the Wheatstone.

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ANOTHER POINT SCORED BY ELECTRICITY.—We learn from the *Mouvement Industriel Belge* that the insurance companies refused to take the buildings of the Antwerp Exhibition of next year if gas were used in the interior; and so the buildings, or at any rate the main portions, are to be illuminated exclusively by the electric light. Independently of the motive power, about 350 h.-p., it is estimated that the expense will amount to about 80,000f., or £3,200, unless the electric light companies switch on some current gratuitously. We further learn that the committee of the electrical section is actively deliberating the matter, but that the details are not yet decided, on account of the expense.

ELECTRIC LIGHT IN CARRIAGES.—We have certainly seen lately, at an exhibition in London, incandescent lamps placed on either side of a carriage instead of candles. Such lamps have also been used in one or two instances in connection with accumulators. We now learn, from our contemporary, *Les Modes*, that similar lamps are used for carriages in the Paris boulevards. They are also arranged so as to illuminate the interior of the vehicle, and in some cases a head light, with powerful reflector, is provided for the horse. The arrangement is due to M. Abailard, manufacturer of incandescent lamps, who maintains them for six hours by means of accumulators placed under the seats and charged by a Daniel battery.

PLATINUM IN RUSSIA.—The platinum mines of Russia, discovered in 1824, are near Bogoslowsk, Miask, Newjansk, and Nischnei Tagilsk, in the Ural Mountains. At six places in 1868, 1869, and 1870, from 494,000, 367,000, and 263,000 tons of sand, 6,675, 7,770, and 6,455 pounds of raw platinum were obtained respectively. The metal always contains some other substances; thus Le Play found, in a sample from Nischnei Tagilsk, 75·1 platinum, 1·1 palladium, 3·5 rhodium, 2·6 iridium, 0·6 osmiridium, 2·3 osmium, 0·4 gold, 1 copper, and 8·1 iron. The raw metal is almost entirely sold, at about £14 per pound of pure metal, to England and Paris, where it is refined before it can be worked up into manufactured articles.

TELEPHONE DIFFICULTIES AT PLYMOUTH.—The Joint Committee of the Plymouth Chamber of Commerce and the Plymouth and Devonport Mercantile Association appointed to consider the present position of the Telephone Exchange at Plymouth, Stonehouse, and Devonport, which, with their suburbs, practically form one town, has arrived at conclusions which will be embodied in separate but similar memorials from the two bodies to the Postmaster-General. The memorialists are gratified at the intention of cancelling the onerous restrictions, and that opportunities are now afforded to individual companies to apply for licenses for the formation of exchanges, but deprecate the multiplication of separate systems.

THE CREIL EXPERIMENTS.—We learn from the *Bulletin* of the Cie Internationale des Téléphones that these experiments (for which a sum of £20,000 has been set apart) for the transmission of 100 horse-power through an electric conductor have been deferred, in order to permit of every possible precaution being taken to ensure success. Those concerned in the installation have, most laudably, consented to accept only the bare reimbursement for their outlay. Only that portion undertaken by the Northern Company is complete, and this is not a matter for surprise, seeing that the machines, which are of unusual size, are being studied and executed with the greatest care, while the various accessory instruments are subjected to the most stringent tests.

ELECTRO-PETROLEO-MOTOR. — Herr Siegfried Marcus, of Vienna, has invented a petroleum motor, in which the explosive mixture is ignited by an extra-current spark produced by the interruption of the circuit of an induction coil, at the moment of its de-magnetisation or the change of polarity of the soft iron core. The ends of the coil wires, between which the spark is produced, are so arranged as to approach one another, inside the chamber where the explosion is to occur, to slide one over the other and then to separate quickly. This action is regulated, with reference to the rotation of the magneto-electric apparatus, so that the ends of the wires be in contact while they are magnetised, and separate at the moment of de-magnetisation or change of polarity.

THE ELECTRIC TRAIN AT THE FORESTRY EXHIBITION.—On Monday last, at the London Bankruptcy Court, a meeting was held for the public examination of H. B. Binko, described as of Bunhill-row, London, chemical manufacturer, trading as Binko and Co., but who ran the electric train at the recent International Forestry Exhibition at Edinburgh. At the first meeting it transpired that the train had been taken possession of by Messrs. Dyson and Co., who had seized it in respect of a judgment which they had recovered against the debtor, and who had afterwards let it to him upon a hiring agreement, under which they now claimed the train in question. It was further alleged that the debtor had taken upwards of £20 a day during the time the train was on exhibition.

CHOLERA AND THE TELEPHONE.—The Syndics of Rome and Naples have addressed letters to the President of the Italian General Telephone Company, warmly thanking him for gratuitously establishing telephonic communication between the various hospitals and cholera refuges, by means of which, in a great measure, the spread of the disorder was considerably circumscribed. The president, Commendatore D. Gallotti, in replying, pays a high tribute to Signor Ernesto di Maria, technical director of the central office, who was urged to use the utmost dispatch in placing a telephone instrument at Pendino for the Relief Committee. He succeeded in effecting communication, but could not himself reply to a message, having fallen a victim to the cholera in the discharge of his duty. Of a truth, Peace hath its victims and its heroes no less than War!

THE ELECTRIC RAILWAY AT FRANKFORT.—The towns of Frankfort and Offenbach are now connected by an electric railway, about 4½ miles long, of 39in. gauge. It leads from the old Romerbrucke, Frankfort, through Sachsenhausen, Oberrad, and through the entire town of Offenbach, the trains running over the entire route in about 25 minutes. Two steam engines, of 125 horse-power each, drive four dynamo-electric machines, by means of suitable cables, from which machines the current is conducted through suitable cables and conductors over the entire line. A switch is provided, regulating, governing, and directing the currents, as may be necessary. The conductors consist of tubes slit along their entire length at the bottom, insulated and securely fastened on poles. In the tube a small cylinder slides, from which a conductor extends down to the car and to the dynamo in the car in the usual manner. The railway was built by Messrs. Siemens and Halske, of Berlin.

THE WESTON MAMMOTH LAMP.—The *Electrical World* gives the following description of these lamps:—"The carbon filament is made by carbonising 'tamadine,' Mr. Weston's preparation from cellulose, and is made to have a resistance of from 68 to 70 ohms while hot. The lamps are run in 'multiple series,' that is to say, there are five parallel series con-

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taining four lamps each. The source of the electricity supplied to each 20 lamps is a 20 arc lamp dynamo of Mr. Weston's pattern, having an electromotive force sufficient to sustain a difference of potential of 160 volts between the binding-posts of each lamp. These data, mathematically arranged, give the following equations: $\frac{160 \text{ volts}}{70 \text{ ohms}} = 2{\cdot}3$ amperes strength of current, and 2·3 amperes × by 160 volts = 368 watts = 0·49 horse-power energy of each light. It is said that the actual commercial efficiency of these lamps is 125 candle-power to each lamp, or 250 candle-power to each horse-power.

Speed of Balloons.—At a recent meeting of the Paris Society of Civil Engineers, M. de Bruignac gave the following figures of the speed per second attained by cigar-shaped balloons:—Giffard (1852), 3 metres; Giffard (1855), 4 metres; Dupuy de Lôme (1871), 2·8 metres; Tissandier (1883), 3 metres; Renard and Krebs (1884), 5½ metres; Tissandier (1884), 4 metres. The only propeller hitherto employed was the screw, which might be placed fore and aft, on the car or at the centre of resistance. It had hitherto invariably been placed in the rear of the car, until Messrs. Renard and Krebs placed it in front; but it increased the resistance when in this position. An elongated car with smooth surface appeared the best, while the net should be replaced by a smooth covering, as recommended by Giffard. The helm should be of sufficient size, not detached from the car, and placed aft. In conclusion, M. de Bruignac considered that a speed of 10 metres (33ft.) a second might be attained in the actual state of science.

Electrolysis in Preparing Indigo Vats.—F. Goppelsroeder in continuance of his researches on the use of electrolysis in dyeing and printing, gives a description of the method adopted by him for the preparation of the alkaline indigo vat. He mixes finely divided indigo with a concentrated solution of caustic potash, and fills a copper vessel half full with mixture, as also a porous cell, which is then placed into the copper vessel. The latter communicates with the negative pole of a galvanic battery or dynamo machine, whilst into the solution contained in the porous cell a large platinum plate is placed which forms the positive pole. The apparatus is then warmed gently, and the current passed through during three or four hours. At the negative pole, *i.e.*, in the copper vessel, hydrogen is liberated with the formation of much froth and the characteristic odour of the indigo vat. The indigo blue is converted into indigo white, which dissolves in the alkaline solution. The resulting yellowish-green vat is then used for dyeing cotton fabrics indigo blue.

Chrysanthemums and Electricity.—The usual Chrysanthemum Shows are now being held in the Temple; and the new varieties, distinguished by pink cards, are creating much interest among those who are able to snatch a moment during the day to visit them. But the show is limited by the fast-decreasing days. How many toilers, whether by hand or brain, would gladly inspect these choice flowers if they could do so, as at the Healtheries, after business hours. We should think some of our manufacturing friends—amateur horticulturists, perhaps—would only be too glad to send a storage battery with a few incandescent lamps to light up the show for a few hours at night. If not, the coppers dropped into a box by an appreciative public would more than pay for the temporary installation. During Mr. Bolckow's *conversazione* given to the Iron and Steel Institute at Middlesborough last year, the conservatories and ferneries were lighted up by secondary batteries sent down from London the previous day, and the novel effect was much admired.

Formation by Electrolysis of Oxy-cellulose and Chloro-cellulose.—Herr F. Goppelsröder contributes the following remarks on this subject to our *confrère*, *L'Electricien*:—"I communicate the first results which I have obtained, while seeking to modify cellulose into oxy-cellulose or chloro-cellulose by electrolysis. For instance, on immersing a cotton tissue in a solution of saltpetre, chloride of sodium, or chlorate of potassium, neutral, acid or rendered alkaline, there occurs, on placing on the top a platinum sheet as positive electrode, and causing the current to pass for a certain time, a change more or less intense, more or less deep of the cellulose, so that, after this operation, it has an affinity for certain colouring substances, methylene blue, for instance, just as if it had been treated with a mordant. On dyeing in a bath of methylene blue or aniline or fuschine green, &c., and on well washing with boiling water, all the places which had been touched by the positive pole appear of a darker blue than the other parts of the stuff, which are but slightly coloured, according to the degree of purity of the cellulose employed."

Electric Current at Berlin.—We learn from *L'Electricien* that the German Edison Company has opened its first great central station in the basement of a house in the Friedrichstrasse, for the production and house-to-house supply of current. There are four large dynamos for maintaining two thousand 16-candle incandescent lamps and three others for 18 arc lamps, each dynamo being driven direct by a 65 horse-power steam engine, making 275 revolutions a minute, steam being generated by three tubular boilers, each of 100 square meters (1,076 square feet), heating surface placed in the court-yard. The current generated by the four incandescent-lamp dynamos is transmitted by copper conductors to a central switch, which distributes it over the cables and wires of the system. Each of the latter is provided with an Edison counter for checking the quantity of current supplied to the various customers, and also with special instruments which the electrician has at his command for ascertaining if the conductors work well, if his lamps burn satisfactorily, and how many there are alight, and also regulators which permit of proportioning the current to the requirements of subscribers. Special arrangements have been made to deaden the sound of the street and from the machines.

Telephono-Thermometer.—In the *Bulletin* of the St. Petersburg Academy of Science, Dr. Lenz describes a new application of the telephone to measuring temperatures at a distance. Let two stations, A and B, be connected by two wires, one iron and the other silver, soldered at both ends. If the solder joint of A be at a different degree of temperature to that of B, a thermo-electric current will circulate through the wires. Given an interruptor and a telephone introduced into the circuit, and the telephone will speak until the observer, placed at B, raise or lower the temperature of his solder joint so as to make it identical with that of A, and in this case there will no longer be a current. The correctness of this method depends upon the precision with which the moment can be determined when the telephone ceases to speak, for a certain resonance continues after the equalisation of the temperatures at the two ends of the instrument. In the first series of experiments, the stations A and B being only distant one metre, Dr. Lenz determined the temperatures with great precision, the errors only varying between 0·01° and 0·17°. He concluded therefrom that, by the use of iron and silver wires 2 mm. thick, the observations might be extended to 5 kilometres (three miles), or even five times that distance, if bismuth and antimony wires were employed.

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ELECTRIC LIGHT IN FRANCE.—The French Edison Company has lately put down plant for lighting the Cosmydor Soap Works, at Levallois-Perret, a suburb of Paris, with 50 A lamps; the works of the French Linoleum Company, at Olry, with 100 A lamps; the Hyat and Ward celluloid factory at Monville, near Rouen, with 100 lamps; the Grande Chartreuse Distillery; the Montgolfier Paper Mills; the Lemaire-Dellis Spinning Mills; and the Bucharest Theatre, with 1,500 Edison incandescent lamps. This last-named installation (we learn from the *Bulletin* of the Compagnie Internationale des Téléphones) has actually been ordered by the Bucharest Gas Company, to which the work was entrusted; while the Lemaire-Dellis Spinning Mills, which were totally destroyed by fire due to gas, have been re-erected without any provision for that dangerous and deleterious illuminant. Besides their own installation, the proprietors have put down plant for maintaining 500 incandescent lamps for their neighbours. The Edison Company is now making small dynamos for running twenty 6-candle lamps. In the installation lately put down by this company for Hatchette's publishing house in Paris, the three dynamos (one for 200 lamps and two for 60 lamps each) are arranged so that they can supply current to each other's circuit in case of breakdown in one of them.

THE INSTITUTION OF CIVIL ENGINEERS.—The council of the Institution of Civil Engineers invite original communications on any of the subjects included in a list, which may be obtained from the secretary, or on analogous questions. For these, if approved, they will award premiums, arising out of special funds bequeathed for the purpose, viz.:—1. The Telford fund, which produces £250 annually. 2. The Manby donation, of the value of about £10 a year. 3. The Miller fund, which realises £160 per annum. 4. The Howard bequest, the annual income of which amounts to rather more than £16. The council will not make any award unless a communication of adequate merit is received, but will give more than one premium if there are several deserving memoirs on the same subject. In the adjudication of the premiums no distinction will be made between essays received from any one connected with the institution (except in the cases of the Miller and the Howard bequests, which are limited by the donors), or from any other person, whether a native or a foreigner. Among the subjects included in the list we notice the following as coming more especially within our readers' knowledge and practice:—Machines and measuring apparatus for testing metals, and the equipment generally of mechanical laboratories; the thermic properties of metals commonly used in the arts, especially with respect to conductivity and diathermancy at high temperatures; mechanical power on tramways, including steam, compressed air, electricity, cables, &c.; electro-motors, their theory, practical construction, efficiency and power; on gearing for dynamo machine motors and other high-speed machines; the transmission and distribution of electricity over large areas for lighting and for motive power, including electric railways, hoists, &c.; electrical measuring instruments; submarine telegraph cables, their manufacture, laying and repair, including deep sea sounding; telpherage, or the automatic electrical transport of goods and passengers; the measurement of work by dynamometers, with descriptions of the apparatus. Instructions for preparing communications and regulations as to proprietorship accompany the list. Among the premiums awarded for the session 1883-84 we notice that the Miller scholarship was granted to Alfred Richard Sennett, Stud. I. C. E., subsequently elected Assoc. M. I. C., for his paper on "The Electric Light."

STORAGE BATTERIES.—An excellent article over the well-known initials "O. J. L." appeared in a recent number of *Nature*. The author of the article pointed to the great desirability of storage, and examined the causes of partial failure. While mentioning one of the main objections to be the loss of energy, he pointed out that where the whole energy would otherwise be wasted, the storage of even 50 per cent. is a clear gain. We benefit also by storage when a fitful and irregular supply of energy is changed to a regular and continuous supply, and again a weak supply may perhaps be stored to give for a short time a storage supply. The various forms of storage battery are considered and their weak points discussed; such are, in the positive plates, the scaling of the plates, the non-circulation of the acid, the buckling of the plates, defective contacts, &c. The author goes on to say:—"The age of plates is a point of vital interest, though but little is known as to the possibilities in this direction at present. A year may be regarded as a fair average age at the present time; but this a low rather than a high estimate. Thick plates are found to last far longer than thin, which is only natural when it is remembered that the wearing out is due to corrosion, that corrosion proceeds mainly from the surface inwards, and that the internal portions of a thick plate are to a great extent protected by the mass of superincumbent material. If it can be shown, as we understand it can, (1) that the cost of materials is far more than the cost of manufacture; (2) that the worn-out material has a market value not incomparably less than the original; and (3) that the frequency with which plates have to be renewed is not such as to cause much inconvenience; then we hold that the first stage of the durability difficulty has been overcome. Much more may be hoped for in this direction as experience increases, and it is not extravagant to hope that a well-ribbed, properly clamped, and fairly-treated thick plate may last as long as five years before it becomes disintegrated." Another point of great interest, and one too often overlooked, is thus stated:—"It is not to be supposed that one type of cell will answer every possible demand. A dynamo to be highly efficient must have a large and massive field magnet, but in some places bulk and weight are fatal objections, and in these places smaller and more compact dynamos may be more suitable; something, however, must be given up to secure the required lightness and compactness, some sort of compromise must be effected. Just so with cells. We can point out what is theoretically the best form, and this form may, for large stationary electric light or power installation, be actually the most suitable; but we may also see that for boats, for tramcars, and for fish torpedoes, some very different and far more compact form may be quite essential." After a similar but short discussion of the negative plate the article concludes:—"The subject of the electrical storage of energy is really one of national importance; it is comparatively a small matter whether this or that form of storage, or this or that company of manufacturers, succeeds in bringing out the permanent form. It sometimes unfortunately happens that enterprising pioneers only clear the way, and retire just in time for other men to come in and reap the fruits of their labours. So much capital and so much labour have been already expended in the effort to bring storage batteries to perfection, so great progress has been made, and so apparently small are the steps which yet remain to be accomplished, that we may surely fairly hope that some of the original believers in their great, and as it seems to us inevitable, future may yet live to see their faith justified and their patience rewarded, and may even taste some of that so-called 'substantial' reward without the hope of which great commercial enterprises would never be undertaken, and modern civilisation would have scarcely yet begun."

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NEW UNIPOLAR DYNAMOS.

BY JNO. M. M. MUNRO.

So-called unipolar dynamos occupy a position in the electrical world similar to that of rotary engines in the world of steam. Theoretically they are very perfect, but practically they are very difficult to construct. At least, the E.M.F. of all the forms hitherto tried has been so low as to make the machines useless for nearly all every-day purposes. I am not aware that any one has tried the device of running two armatures in contrary directions.

Some three or four years ago I began some experiments in this direction, but had to lay them aside for others of more immediate practical use. My chief aim at that time, however, was to construct a dynamo in which the mutual action of two armatures, either with or without iron, and running in opposite directions (or one stationary the other moving), would

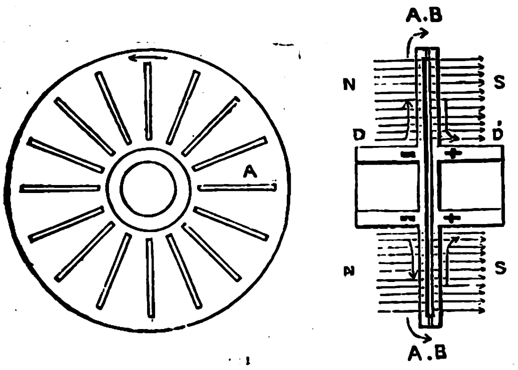

Fig. 1.

supersede the usual armature and field magnet. Each armature was to act as field magnet for the other, residual magnetism being represented by the earth's field or a small current from a cell. I became convinced, however, that although such machines might be interesting, the slight gain in efficiency would not compensate for the various disadvantages. Probably the same remark applies to the proposed unipolar dynamos, which I will now describe.

The field is produced by two long massive E magnets. The pole pieces consist of a great number of soft iron rods screwed into the poles of these magnets. In some forms of these dynamos

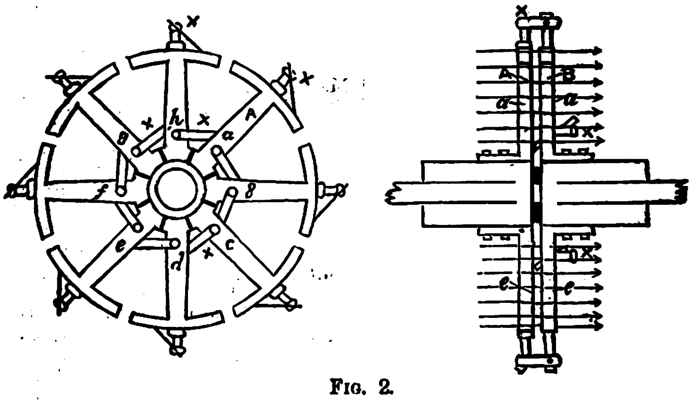

Fig. 2.

the armature is cylindrical, but the radial forms will be the more easily described. The rods forming the E magnet pole pieces take in the mass the form of circles corresponding to the armature, and this circular bundle of rods has a few turns of wire wound round and within it to reinforce its magnetism. The faces of these circles approach each other north against south, producing a very intense uni-directional field in which the armature may revolve. In Fig. 1 consider armature as two copper discs slit radially to avoid eddy currents, but continuous round inner and outer edge. These are suitably mounted and rotated in opposite directions. As in all armatures, the currents react on each other, in this instance favourably and unfavourably alternately, but the E magnets abundantly overpower all such action. Projections P P′ from the inner edges of armatures form the terminal poles from which the current is drawn, as well as drums by which they are driven. The outer edges run against each other. In this way the E.M.F. is double that of a single plate, for the current flows from the negative pole outwards in one armature, A, passes into the other B at its outer edge, and thence inwards to the positive pole. It would be possible by more complicated arrangements to increase the number of these discs, and therefore the E.M.F., but I will describe more simple ways of attaining this end. Thus the armature in Fig. 2 has its discs built up of separate insulated radiating bars. Contact is made by brushes X and other appliances between the outer end of each bar of A armature and the outer end of the nearest bar of B armature. The inner ends are similarly united, but the connection is made not to the nearest bar of A, but the one next it. In this way there is a continuous circuit right round the two rings; outwardly in *a* bar of A,

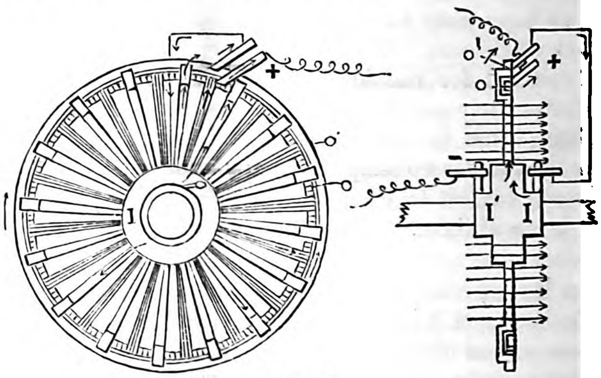

Fig. 3.

inwardly in *a* bar of B, across to and then outwards in *b* bar of A, then at outer end into *b* bar of B, and thence downwards, then into *c* bar of A, and so on. Of course the the necessity of having so many sliding contacts neutralises one of the chief benefits of a unipolar dynamo. At a certain point in the circumference the continuity of this circuit is broken, and the two ends are connected to two rings not shown, one running with each armature, and these rings form the two poles of the combined armature.

In Fig. 3 we see only one disc, two outer rings, O O′, and two inner rings or bosses, I I′. The radial bars are connected to

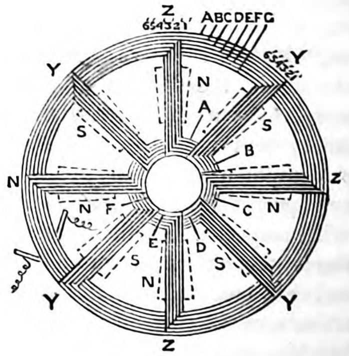

Fig. 4.

the one or other of these alternately. The current enters by I′, passes outwards along every second bar into ring O′, thence by brushes (which may be numerous to reduce resistance) and wire to I, and then outwards in the remaining bars to ring O, and thence to external circuit. If higher E.M.F. is required more rings may be added. The two machines next described hardly fall within the scope of the title of this article, yet they are in many points closely related.

In machine Fig. 4 we no longer use "unipolar" currents, but two crowns of *b* magnets similarly arranged to those of Siemens's alternate current machine or the Thomson-Ferranti. The armature consists of groups of radial bars equal in number to the E magnets on each side. There must be as many inner rings as there are bars in the group, and of the outer

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rings there must be one more. Each group is always cutting through a field of opposite direction to that through which the contiguous groups are passing, and the currents in any two neighbouring groups, therefore, are always flowing in opposite directions. Let it flow inwards from ring A in No. 1 bar of groups marked Y; it will then flow from these round the outermost of the inner rings, marked A′, and thence outwards in No. 1′ bars of groups Z. But these bars do not reach to A but only to B. This puts them in series with No. 2 bars of Y, which descend to B′. From B′ spring bars No. 2′ of Z, and these end in C ring and so on. Rings A and G form the terminals of machine. The currents are alternate. The arrangement for continuous currents is not so easily shown by a diagram. There are more rings and more bars and fewer magnets. The inner rings are furnished with projecting pieces so disposed that they form an ordinary sectional commutator with a gradual

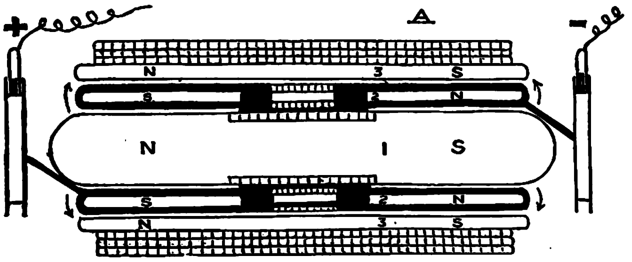

Fig. 5.—Longitudinal Section.

fall of potential in the contact plates both ways from the positive to the negative sides. Only one pair of brushes are necessary, as parts that are at the same potential are always connected together by the same rings. Figs. 5 and 6 show a unipolar dynamo. 1 is a round E magnet with a depression in the central third of its length in which is wound a layer of wire (wire being always of rectangular section). When the other arrangements of the machine permit, a second layer of wire is wound upon this in the more central part. Around this is constructed a cylinder composed of long straight bars of softest iron 3.3. These bars are magnetised by layers of wire wound across them individually, but around the cylinder, and concentrically with the surface of the round magnet 1. In the space between the cylinder 3 and the round magnet 1 the armature, also cylindrical, revolves. The core 2 of the armature consists of iron rods similar to 3 except that

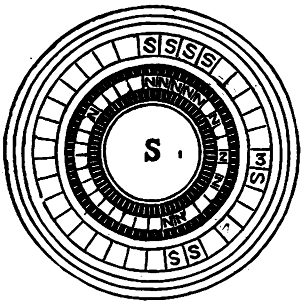

Fig. 6.—Transverse Section at A.

at two points, situate fully two-thirds of the way from the ends to the middle, they have slots cut in their sides so as to allow the conductors to pass from their inner to their outer surface. These slots are not deep, but are of considerable breadth, the conductor at this point taking the form of very thin broad plates, suitably insulated with mica and paper. The conductors on either end of these magnets are arranged so that they form a continuous spiral, just like two Gramme rings. The broad black lines are the conductors. The one end of the left hand spiral is attached to a ring which forms the positive terminal. The other end is connected through the right hand spiral to the negative ring. The magnets of armature may have wire wound round their middle parts. This cylinder, 2, of E magnets forming the core may be fixed, but that construction is most difficult, and I do not think that their motion will be injurious to the working of the dynamo. Of course there is no changing of its magnetism as it rotates. The armature is rotated by means of drums, to which are affixed bars which pass along the armature, or, if preferred, clasp the armature by its ends suitably insulated. With a different form of outer magnets the armature can be driven by its middle part.

ELECTRIC TRANSMISSION OF POWER IN MINES.*

BY PROFESSOR W. S. SCHULZ.

The author deduces from the executed electrical transmissions of power tabulated below that the maximum electrical efficiency of the receiving dynamo practically attainable is 50 per cent. of the transmitting motor:—

Name of Pit.	Power of Motor.	Machine Driven.	Length of Lead.	Efficiency.		
				Electrical.	Mechanical.	Total.
	h.-p.		Metres.	P.c.	P.c.	P.c.
La Peronnière, near Rive-de-Gier ...	37·1	Hauling-Machine	1,500	50·0	37·0	30
Thibaut, near St. Etienne	5·0	"	250	45·0	38·0	25
Blanzy	17·0	"	634	...	51·0?	30
Zaukeroda	14·7	Loco.	893	46·6?	37·8?	30
"	5·0	Fan	780	50·0	26·0?	...
St. Claude, near Blanzy	8-10	"	900	...	...	...

On this basis he compares the cost of electrical transmission of power with the actual cost of transmission by compressed air and water applied to rock-drills and coal-getting machines, locomotives, cable and rope-hauling machines, and ventilators, and finds the former more costly than other methods, except where air is compressed by steam power without being cooled, and in the case of locomotives for haulage on levels. The comparative cost of such haulage in actual operation is given in the table:—

Underground Haulage by Locomotives.

—	Steam.		Compressed Air.		Electricity.
	Dornan Pit.	Cesson Pit.	Petan's System.	Mékarski's System.	Zaukeroda Pit.
	Marks.	Marks.	Marks.	Marks.	Marks.
Cost of plant	32,000	32,000	13,000	20,000	16,000
	d.	d.	d.	d.	d.
Interest, &c., per ton-km.	0·264	0·091	0·490	0·502	0·276
Cost of haulage " "	0·372	0·316	0·736	0·841	0·680
Total cost " "	0·636	0·407	1·226	1·343	0·956
	Ton-kms	Ton-kms	Ton-kms	Ton-kms	Ton-kms
Daily work..................	488	1,421	106	159	235
	Metres.	Metres.	Metres.	Metres.	Metres.
Length of line	2,320	4,627	620	620	620
Speed "	2·3	3·3	1·5	1·5	2·6
	Kilogms.	Kilogms.	Kilogms.	Kilogms.	Kilogms.
Weight of engine.........	4,400	8,000	2,700	2,300	1,600
	Metres.	Metres.	Metres.	Metres.	Metres.
Height " "	1·92	2·1	...	1·55	1·5
Width " "	1·30	1·6	...	1·10	0·8

For the separate ventilation of a lateral drift of the Zaukeroda mine† a 40in. Schiele fan is used, driven by a Siemens dynamo actuated by a Dolgorouki steam engine; the cost per 1,000 cubic metres is 0·27d., which is cheaper than transmission by compressed air only where a special compressing plant for the small fan has to be put down. The author concludes that there is no field for electrical transmission in mining, special cases excepted, except for hauling on levels by locomotives, which could advantageously replace rope or cable-haulage.

* *Proceedings* Institute Civil Engineers.
† Minutes of Proceedings Inst. C.E., Vol. LXXIII., p. 474.

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ELECTRICITY AS A MOTIVE POWER ON RAILWAYS.*

BY BARON GOSTKOWSKI.

The author first inquires into the use of primary batteries (instancing Page's locomotive, 1850), and then into the use of accumulators, and showing that they cannot at present be used for ordinary railways on inclines on account of their weight. He then passes to the cases in which the current goes direct to the electro-motor on the locomotive first introduced by Siemens (Berlin, 1879). In this case the current passes from the two rails through the wheels. In the case of the electric locomotive at the Paris Exhibition (1881), and the recently-opened line between Mödling and Brühl, the current passes to the electro-motor through a copper tube the whole length of the line, in which slides a piston which the car draws along with it. On the Portrush Railway there is a third rail, on which runs a contact wheel forming the positive lead, the two running rails forming the negative. Which of these three systems is best yet remains to be seen. The following applies to all. The mechanical work necessary to supply a current of C amperes and E volts is—

$$\frac{C.E}{g} \text{ kilogrammetres,}$$

where g is the acceleration = 9·81 metres. The available work of the motor will be

$$\frac{C.e}{g} \text{ kilogrammetres,}$$

where e is the electromotive force at the motor. The loss of work is $\frac{C}{g}(E - e)$ or R being the total resistance,

$$\frac{C^2.R}{g} \text{ kilogrammetres.}$$

The object is to minimise this loss. This is to be done, supposing R constant, by making C as small as possible. This entails a high electromotive force, which involves better insulation, and so increases cost. It is thus seen that the values of C and e must be so chosen as to make the cost as small as possible.

It is found that about 30 per cent. of the work is lost. This, taken in connection with the result of experiments made in the Paris workshops of the Northern Railway of France, gives

$$\frac{e}{E} = a = 0{\cdot}83.$$

If, then, p is the work furnished by the motor in kilograms per second

$$\frac{C^2.R}{g} = 0{\cdot}3p,$$

but $$C = \frac{E - e}{R} \text{ and } \frac{e}{E} = 0{\cdot}83,$$

therefore $$E = 10\sqrt{p.R} \quad \ldots\ldots \quad (1)$$

Further, according to Uppenborn, it is best to have the internal resistance $\frac{3}{7}$ of the external resistance.

And if r_1 = resistance of generator,
r_2 = " motor,
r_3 = " conductor,

$$r_1 = \frac{3}{7}(r_2 + r_3).$$

If similar machines are used for generator and motor

$$r_1 = r_2,$$

in which case $$R = r_1 + r_2 + r_3 = \frac{5}{2} r_3.$$

If 1 kilogram of conductor has a resistance of $\frac{1}{5}$ ohm, and the distance between generator and motor is l kilometres, then (allowing for two conductors),

$$r_3 = \frac{1}{5} \cdot 2\,l = \frac{2}{5}\,l,$$

in which case $$R = \frac{5}{2} \cdot \frac{2}{5}\,l = l \text{ ohms,}$$

substituting in (1) $$E = 10\sqrt{p\,.\,l} \quad \ldots\ldots \quad (2).$$

From this the electromotive force can be calculated for a line l kilometres in length, where p kilogrammetres per second must be supplied.

For an electric railway, where the motor is required to do as much work as a 300-cheval-vapeur (295·89 H.P.) steam engine on an ordinary railway,

$$p = 300 \times 75 = 15^2 \times 10^2 \text{ kilogrammetres,}$$

and from (2) $E = 1{,}500\sqrt{l}$ volts.

On a line 4 kilometres long, therefore, an electromotive force of $1{,}500\sqrt{4} = 3{,}000$ volts would be required, a tension which could scarcely be permitted. Assuming the practical maximum at 500 volts, there would be required in a line 4 kilometres long at least $\frac{3{,}000}{500}$ = six generators and as many motors, which would be far from economical. It is for this reason that the lines at present made are only short.

In the case of an engine worked by accumulators, the weight of the accumulator was found to prevent their advantageous use on ordinary railways; in this latter case, however, the limit is the difficulty of insulation.

Name of Railway.	Length in Miles.	Greatest Inclination Inches per Mile.	Speed. Miles per Hour	Current in Amperes.	Total Resistance in Ohms.	Electro-motive Force in Volts.
Mödling Brühl	0·93	0·95	12·3	40	0·7	350
Lichterfelde ...	4·35	...	12·3	...	...	90
Beuthen	0·5	...	8·9	37	1·6	1,000
Portrush	6·21	1·58	6·9	...	1·5	500

* *Proceedings* Institute Civil Engineers.

THE PHILADELPHIA EXHIBITION.—V.

(FROM OUR SPECIAL CORRESPONDENT.)

PHILADELPHIA, OCT. 10.

The Electrical Exhibition is to be closed to-morrow evening. It has been very successful, and has already more than paid all expenses, including the erection of the building at a cost of $35,000. It is probable that there will be a cash profit of $20,000, and the Institute will hold the building for a few years for the purpose of giving other specialty exhibitions. It is not a permanent structure, but may outlast two or three exhibitions, giving a chance to make larger profits. The Institute has also gained by the display of a library on electricity comprising about 2,000 books and pamphlets, and quite a large museum of electrical inventions and models.

The examiners are much behind time with their work, and the engines will be kept at work for two or three weeks after the close of the Exhibition to enable them to make their tests. There are already signs of trouble. Some of the reports are being made up, without tests, on the judgment of the examiners, based upon statements of exhibitors. These are likely to be rejected by the full Board. There is a strong feeling now amongst the engineers who have spent time in making careful tests to call a special meeting of the full Board, and have a resolution adopted refusing to make or publish any reports except such as are based upon actual trial by the sub-committees of the Board of Examiners. If this is done it will add a great deal to the value of the reports. The exhibitors are getting very nervous over the matter, some because of faults in their machines, which they recognise, and others because they have not full faith in the ability or methods of the examiners. This, however, is an old story of exhibitions where competitive trials are made. The Board of Examiners, it may be said, is constituted of fair-minded men, and a large majority are fully competent to make the tests.

Of the Exhibition itself it is to be said that it has been very well managed throughout. A distinguished English electrician says that though it cannot be compared with the Exhibitions

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of Paris or Vienna with respect to size or expensiveness of exhibits, and is not, properly speaking, an international exhibition, it is nevertheless of greater scientific interest than any previous electrical exhibition, and a finer display with respect to variety of inventions than any nation of Europe could organise.

Some weeks ago I wrote to you about a mysterious lamp in the Edison exhibit, which was supposed to show conductivity in a vacuum. It had, your readers will remember, a third electrode (a platinum strip) within the loop of carbon, but separated therefrom. A current being passed through the lamp, and connection made between the positive pole and the platinum through a galvanometer, strong indications were given of the passage of a current, the space between the carbon and the platinum becoming in some way a part of the conductor. When connection was made in the reverse way the deflection of the galvanometer was scarcely appreciable. It is now supposed that the phenomena is due to a Crooke's bombardment, and that atoms of carbon bombard the platinum and furnish the conducting medium. To account for the smallness of the deflection when the reverse connections are made, it is pointed out that the platinum offers greater resistance to the action of the current than the carbon. Edison has prepared another set of lamps. One of these has a horizontal tube leading out from the side of the bulb opposite the filament. The platinum electrode is placed at the end of the tube. The bombardment (assumed) is direct, and the galvanometer shows the passage of a current. Another lamp is precisely similar, except that the tube is bent at right angles, and the platinum electrode is thus removed from the direct line of bombardment. The galvanometer shows no current between the carbon and the platinum.

A great variety of underground systems for electrical conductors is shown. Nine-tenths of them are mere mechanical contrivances to provide a hole in the ground through which insulated wires may be laid. Some of them are very ridiculous. One that I call to mind has great plates of hammered glass separating a copper trough into compartments. The glass slabs, placed 4ft. to 6ft. apart, are pierced with holes, through which the wires are to be strung. It is needless to say the inventor presents no estimate of cost. Another contrivance is an arrangement of iron curbs and gutters which form covers to a subway. The only system electrically complete in itself is that of David Brooks of this city, who has, I believe, four miles of his pipe laid in London on trial. In this system cotton covered wires in cable form are drawn through small iron pipes, which are then filled with paraffin oil, which is kept under pressure by being connected with reservoirs placed at the high points of the system. Mr. Brooks has eight miles of this conduit laid down in this city, through which telegraph and telephone wires have been worked for several months. Since the Exhibition opened he has made a contract with the Western Union Telegraph Company to put all its main lines in this city underground.

One of the deficiencies of the Exhibition has been the want of an electric railway. A miniature line was laid down, but of an untried system. Another railway of full size has been laid on Thirty-second Street within a few days, and is to be opened to-morrow—the last day of the Exhibition. It is to be run by a Griscom motor of 15 horse-power. This motor differs from his small sewing machine motor in having a Gramme ring in place of a Siemens armature. The magnet is of the ring form, It is an entirely new machine, and is to be put in operation at this late day only to secure tests. Connection is made with one outside or running rail, and a central rail used only as a conductor, not through the wheels, but by means of brushes.

Drawbaugh's exhibit of telephones attracts a great deal of attention, and is rather amusing than otherwise. All the telephones owned by the Bell company are duplicated in this collection, and are alleged to have been invented prior to 1876, the carbon transmitter as early as 1864. The queer part of it is that Drawbaugh apparently abandoned perfect instruments to experiment with others, and has finally patented twenty-two carbon transmitters, no one of which is as good as his original device, which he did not patent.

ELECTRICITY AT THE BREWERS' EXHIBITION.

We were pleased to find that electric lighting was carried out to a larger extent at the Sixth Annual Brewers' Exhibition, held last week at the Agricultural Hall, than it had been at the Dairy Show, held a fortnight previously. What is wanted, however, is a comprehensive installation for thoroughly illuminating the whole premises, where one show or exhibition follows another in quick succession. In view of the rapidly approaching Cattle Show, the Agricultural Hall Company should invite a few leading electricians to send in a project and estimate for thoroughly illuminating the building. And now that so much plant is set free by the close of the Health Exhibition, and this great means of keeping the various systems before the public is at an end, the offers should be very low, if not absolutely gratuitous, as, during the Cattle Show, there will be motive power in abundance. It is well known that some of the abnormally fat beasts have before now succumbed to the London fog; and it seems no more than humane to adopt any means for preventing unnecessary vitiation of the atmosphere.

But, to return to the Brewers' Exhibition. The Electric Lighting Supply and Fitting Company, of York-street, Westminster, whose arrangements to afford light in darkness at the Dairy Show had been to a considerable extent frustrated by disappointment in their motive power, had this time provided themselves with one of Marshall's portable engines of 12 horse-power nom., which drove three Franklin dynamos and an exciter; but even on this occasion we noticed that some of the incandescent lamps were not giving out their full quantum of light. One 1C Franklin dynamo, making 1,800 revolutions a minute, gave out 300 volts at 20 amperes, and fed five Brockie 2,000-candle arc lights, of which two illuminated the stand of Sir Joseph Causton, Sons, and Co., printers. Two C2 Franklin dynamos at 1,800 revolutions, giving 140 volts at 35 amperes, maintained sixty 20-candle 100-volt Swan incandescent lamps. The field-magnets of the three machines above named were excited by a 1B Franklin dynamo giving, with 1,800 revolutions, 200 volts at 20 amperes. The incandescent lamps, distributed about the stands of several exhibitors, were provided with porcelain reflectors. In addition to the current produced by the dynamos, two Holmes-Burke primary batteries of 7 cells, giving 25 volts at 20 amperes, maintained twelve 10-candle 20-volt Swan incandescent lamps, fitted to the gas pendants of Messrs. Borroughes and Watts' billiard tables, supplied for the tournament. Moreover, two Holmes-Burke primary batteries of 5 cells, giving 18 volts at 20 amperes, supplied the current for lighting the stand of Messrs. Haselgrave and Co., of Leeds, by four 10-candle incandescent lamps, and also for working their patent registering meter for wine, spirits, &c. In this ingenious appliance for preventing the surreptitious abstraction of liquors, a gauged and graduated reservoir is fitted between the cask and the tap. The action of opening the latter closes the circuit, which, however, is interrupted by the ebonite portion of the scale on the reservoir, the metallic divisions only causing the counter to register. Closing the tap interrupts the circuit to the counter, but sends a current through the electromagnet which attracts its armature attached to the float, and so draws it up ready for the next flow and registration. The proprietor switches off the current at night, and thus prevents the possibility of liquor being drawn off; and any tampering with the apparatus also stops the flow.

The British Gas Engine and Engineering Company, Albion Works, London, ran one of their 3½ horse-power horizontal compression gas engines, at 80 revolutions a minute, driving a Gramme dynamo, which maintained twenty-one 20-candle incandescent lamps on their own and the adjoining stands. The light was remarkably bright and steady; and it is claimed that this gas engine (Atkinson's patent), with circular revolving slide-valve, giving an ignition at each revolution, is the only one that will drive a dynamo with sufficient regularity for direct electric lighting, unless there be a heavy fly-wheel on the dynamo, which necessitates working with a slack belt, thus sacrificing one-third of the power.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

CONTENTS.

Notes 545
New Unipolar Dynamos. By J. M. M. Munro. Illustrated 550
Electric Transmission of Power in Mines. By Professor W. S. Schulz 551
Electricity as a Motive Power on Railways. By Baron Gostkowski 552
Philadelphia Exhibition.—V. 552
Electricity at the Brewers' Exhibition 553
Imperial Defences and the Telegraph 554
Correspondence. Illustrated... 555
The Health Exhibition.—XI. Illustrated 556
The Theory of the Dynamo-Electric Machine. By Professor J. Fitzgerald. Illustrated. 558
On the Permanent Temperature of Conductors. (Concluded.) 559
Long-Distance Telephoning in Belgium 560
Ancient Telegraphs 561
Companies' Share List 564

IMPERIAL DEFENCES AND THE TELEGRAPH.

We have shared with the rest of the English public the anxiety created by the revelations of the *Pall Mall Gazette*, and we share, too, the general desire that steps may be speedily taken to remove all ground for apprehension with respect to the preponderance of our fleet or the security of our coaling and naval stations. But when the author of those startling articles came to his concluding remarks, we were somewhat amazed at the recommendation placed first on his list, though we could take no exception to the rest. We had, in fact, felt some alarm on our own account, so to speak, and had wondered that among the unprotected objects of national possessions and commerce referred to by the writer he had made no serious mention of telegraph cables. We had thought that they were a subject of great solicitude, demanding some of that protection which the commerce of the nation would certainly obtain in time of war. But the writer has apparently regarded them simply as aids to warlike defence, and only incidentally as things requiring to be protected. Here are his exact words, copied from the *Pall Mall* of 17th October:—"I will therefore summarise what ought to be done: a telegraphic cable should be laid down connecting West Africa and the Cape direct with England. All our telegraphic communication with South Africa passes through Suez, and would be intercepted in case of war. From the Cape, cable communication should be established with India and Australia. A cable should also be laid to Bermuda. The telegraph stations where the cable touches ground should be placed within fortifications; and this of course applies equally to the English end of the cable. At present a single boat's crew landed at Port Darwin could sever Australia from communication with England, and keep all our commanders in the southern seas in total ignorance, until the mails arrived, whether we were at war or peace."

We wish we could share the *Pall Mall* writer's apparent confidence in the utility of these measures for the purposes of defensive warfare. They strike us, on the contrary, as multiplying the causes of anxiety; and although we by no means deny their usefulness, we do say that they add to the necessity for increasing our naval strength for their protection, just as it is admitted, except by political partisans, that every increase of our maritime commerce demands a proportionate augmentation of our fleet. The notion, fostered by niggardly administrations, that the navy is intended only for our defence against invasion has been happily blown to the winds by the discussion arising out of the *Pall Mall's* revelations; but it ought not to be lost sight of that submarine cables, regarded either as an indispensable medium of trade or as valuable British property, are entitled to the protection which our shipping and colonies would receive as a matter of course. That these cables would be safe in deep sea or be rendered so by landing them under fortified places we cannot admit for a moment. Where this may be practicable it ought to be done, and such an incident as that pictured as happening at Port Darwin should be put out of the range of possibility. But, as has been pointed out by Sir James Anderson, a fortification could afford no sort of protection beyond the range of its guns, and to rely on such an expedient would be as foolish as to fasten your orchard gate in order to keep out the birds.

In respect, however, to the advisability of duplicating our cable systems, or rather increasing the number of alternative routes and their points of landing, there can be but one opinion, especially if secrecy could be maintained with regard to routes of some of them at least, and their points of landing. This brings us to the question of Government responsibilities in respect to submarine telegraphy. It is certain that cables ought to be laid to every naval and military station of importance, irrespective of the traffic that is likely to pass over them. Unless the Government undertake this on their own account they must, in such cases, subsidise the private undertakers. When, however, we see on our own shores places, which on military grounds ought to have a telegraph, still left in a worse position than they were in the days of semaphore and beacon, simply because the Postmaster-General does not consider that the traffic would be remunerative, the prospect of seeing the *Pall Mall's* programme carried out is, we fear, somewhat remote. But Sir James Anderson does the *Pall Mall* writer perhaps less than justice in respect to West African and Cape cable suggestions. Evidently they are intended as alternative routes to South Africa and India, on the assumption that the Suez route would be instantly interrupted on the outbreak of war. Sir James declares, with a vigour that is quite refreshing in one who disclaims being a Jingo, that "we are not going to give it (the Suez route) up until we are thrashed out of it." We think so too, notwithstanding Mr. Gladstone's declarations to the contrary not more than five years ago. But the *Pall Mall* distinctly asserts that the cables, if not the commerce, would be intercepted; and if this be the case it only strengthens the need for further defensive appliances in that part of the route to our Eastern Empire.

This indeed is a matter of first importance, more so even than the laying of a cable, or a series of cables, along the West African coast, especially if that scheme is to take the shape set forth in *The Times*, and reprinted in our last week's issue. *The Times'* view of "international complications," when

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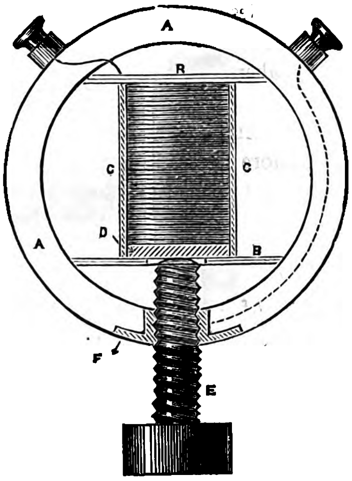
it has a scheme to back up, is highly original. Warned by what happened during the war between Chili and Peru, says *The Times*, the projectors of the West African cable are going to start it from Spain, then touch at various French ports and Portuguese islands or colonies before it is finally planted on British possessions. As we have recently been quarrelling with Portugal about the Congo, and may any day have a fight with France, the avoidance of international complications by this arrangement is not apparent to anybody outside Printing House-square. It seems to us exactly the way how not to do it; and if it be true, as was announced in the *Daily News* last Thursday week that "proposals have been made to the Government for the establishment of telegraphic communication with the West African colonies," we hope that some better arrangement than the one described in *The Times* will be adopted. We are greatly deficient in governmental responsibility as it is. It would be the height of folly to accept responsibility for the benefit of our possible enemies. We should prefer to learn that the proposal referred to by the *Daily News* is the one which has long been submitted to the Government for putting British possessions directly in communication with existing British cables in proximity to the western shores of Africa, and which would be free from most of the objections of the other scheme. What we are in want of just now, however, is a frank recognition that British submarine cables are part and parcel of the British Empire, and require to be guarded and defended like all other vulnerable points of our imperial possessions.

CORRESPONDENCE.

THE ROUSSY ELECTRIC LIGHT MODERATOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the autumn of 1882 I constructed a carbon resistance switch for incandescent lamps. The switch was roughly made, as in the enclosed sketch, in which A was a turned



wooden box of about 2in. diameter by 1in. in depth, having two brass shelves, B B, between which was placed a short length of gauge glass, C, filled with carbon resting on a circular plate of brass, D. Through a hole in the bottom shelf B passed a screw, E, working in a nut, F, inside of box and having a milled head for adjustment, the terminal attachments being to top plate B and nut F. The switch was designed with the double object of enforcing a very gradual switching out of any incandescent lamp with which it might be in circuit, and, within certain limits, of regulating the amount of light given off by the lamp. I first tried thin carbon plates, afterwards finely-broken pieces of carbon, which arrangements I now see are styled respectively the "Stanley" regulator and "Roussy" moderator. For my own part I copied it from the well known Brush regulator, and found both arrangements of carbon to fail in their action as regulators, owing to the cause mentioned in your description of 25th October. It will be interesting to learn the exact means by which M. Roussy has overcome this difficulty.—Yours, &c., R. E. DUNSTON.

27, Gaisford-street, Kentish Town, October 26.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to your article in *The Electrician* of the 25th inst. on the Roussy electric light moderator, I beg to inform you that I designed the same apparatus about three years ago, and it was used by the Duplex Electric Light Company. As regards permability of resistance its performance was perfectly satisfactory, but, owing to improvements in generator, its services were dispensed with.

I found by experimenting that carbon in a granulated form (granules about the size of hemp seed) was the most suitable. I first tried discs and experienced same difficulty as in the Stanley moderator. I discarded powdered carbon on account of the difficulty in adjusting it, the smallest alteration of tension considerably affecting its resistance.—Yours, &c.,

ST. GEO. W. DAVEY.

Sheffield, October 29th, 1884.

THE ELECTRIC ENGINE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to the electric engine illustrated in *The Electrician* last week, may I be allowed to point out that these engines may be obtained in several ways other than by purchases from the Coalbrookdale Company? The following recipes for their production may be useful:—(1) Take an improved Brotherhood engine; remove two of the pistons and piston valves, and drive the governor by a belt. (2) Take a Westinghouse engine, and admit exhaust steam into the crank chamber, having previovsly disconnected one of the working pistons. (3) Take a Willans two-cylinder compound engine, and work it always as a simple engine; a connection must also in this case be made between the crank chamber and exhaust pipe, so that the escaping steam may have free access to the bearings.

Any of the above arrangements will apparently make an electric engine, and the parts removed will always be useful as spare gear.—Yours, &c., J. W. WILLANS.

Thames Ditton, Surrey, October 27.

THE EARTH AND ITS RELATION TO TELEGRAPHY AS A *RETURN* WIRE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: There appears to be a considerable diversity of opinion as to the action of the earth in a telegraph circuit.

Mr. Culley quotes Gavarret's explanation, which in effect treats the earth as a huge reservoir, &c.

In Mr. Sprague's valuable work, "Electricity: its Theory, Sources, and Applications," the theory laid down seems to me to be far more feasible. He concludes that the earth really acts as a conductor without any appreciable resistance, and in thinking this out an idea struck me—that, suppose a long wire giving no appreciable resistance were carried all over the telegraph world, and all the earth wires instead of being joined to earth were joined to this wire of no appreciable resistance, what would be the result?

On the face of it, it looks as if the circuits would be in a state of confusion; but a little thought, I believe, will lead to the conclusion that though all the circuits were joined to this wire they would work perfectly independently of each other, because at the points of junction of the different circuits there would be *no resistance*, and therefore no divided current, and we should have a system *entirely insulated* from the earth but acting (to my mind) precisely in the same capacity.—Yours, &c.,

J. M.

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HEALTH EXHIBITION.—XI.

The PILSEN ELECTRIC LIGHT COMPANY have had a very important part assigned to them in the lighting of the Health Exhibition. The success with which they have executed their work, and the satisfactory manner in which they have maintained their large installation, render the latter worthy of notice. It offers many points of interest to the engineer and the electrician. As an example of progress it claims attention, inasmuch as it includes several novelties, the outcome of experience, and exhibits, partly in consequence, that degree of completeness for which the Bethnal Green installation of the same company is remarkable. The distinctive features of this exhibit will be best understood by setting them out in order.

The dynamos are of the Schuckert type, but the design and construction have been materially modified by the electricians

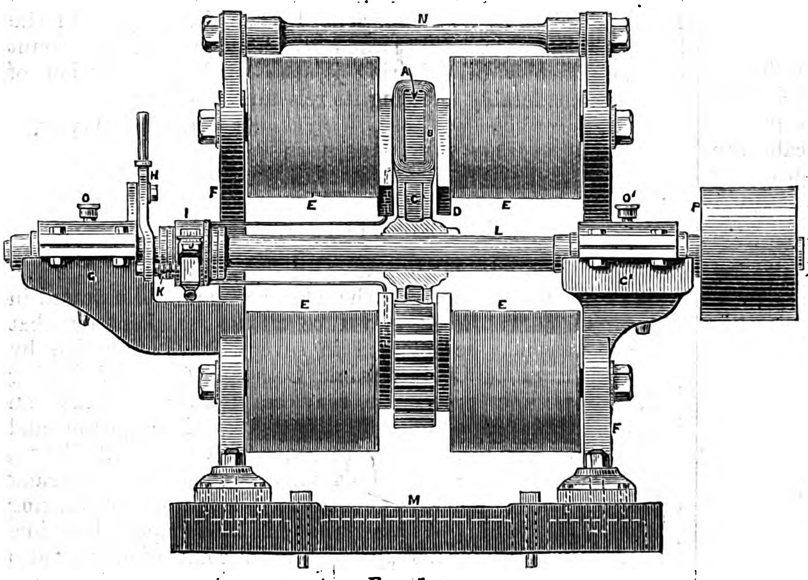


FIG. 1.

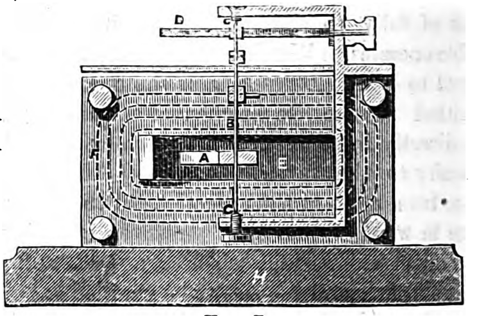
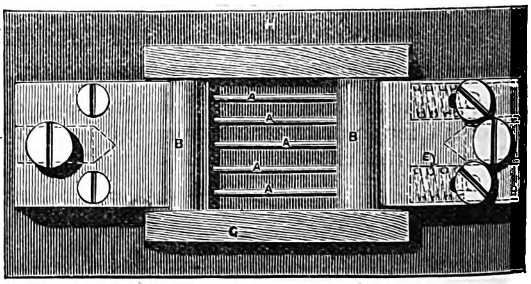


FIG. 3.

FIG. 4.



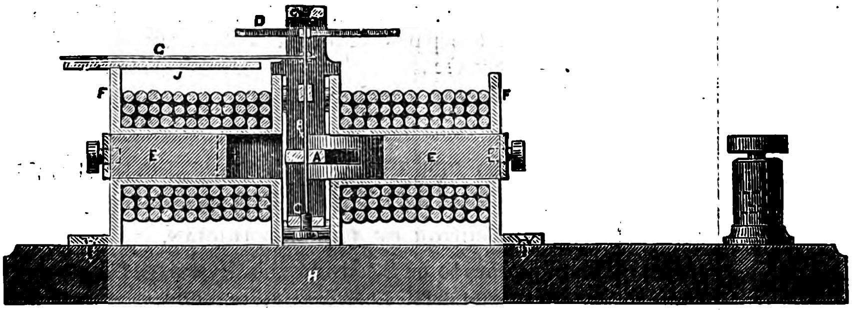


FIG. 2.

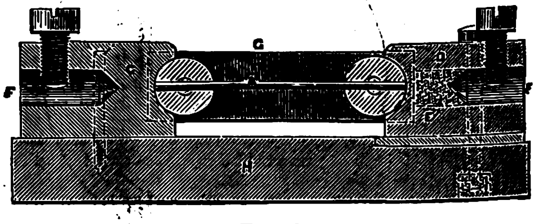


FIG. 5.

of the Pilsen Company. The exhibits are arranged to show clearly the nature of these modifications and the advantages to which they have led. Of the four machines used to maintain the arc lamps, two, those nearest the eastern end, are of the original form devised by Herr Schuckert. The armature in this design consists of flat wrought-iron rings, separated one from another by air spaces, but held together at small intervals by brass rivets and distance washers. Upon the iron core thus built up the wire sections are wound, and the completed ring is mounted upon a metal hub, and secured in position by the friction of metal flanges on either side. The other two machines are of the modified construction of armature introduced by the Pilsen Company, and distinguished as the "Pilsen-Schuckert type." The core of the armature is of soft hoop iron, wound up tightly in volute form. The layers of iron are separated one from another by strips of calico or longcloth wound in with the iron; a sufficient number of turns is given to form the broad flat ring characteristic of the Schuchert type. The sections of wire are wound upon this ring, and the finished armature is fixed upon the hub in the usual manner. Other machines exhibited are of more recent construction, and these have been further improved in the method of mounting the armature. In these machines the central boss carries a number of radiating arms, terminating in a kind of fork, into which the hoop iron is wound directly. This method of mounting the armature allows the latter to be built up of large diameter. The sections of wire on this ring are separated one from another at the periphery by soft iron shoes or wedges insulated from the rest of the iron in the core. These separate pieces increase in a notable degree the efficiency of the machine. The improvements here indicated, besides affording obvious mechanical advantages, have reduced the internal resistance in the proportion of 12 to 7, while the sectional area of the wire has been increased 40 per cent. The increase of efficiency allows for equal external work a reduction of the speed by about 21 per cent. At the Exhibition each of the original type machines maintains 14 arc lamps through about 400 yards of wire leads at a speed of 775 revolutions a minute. Each of those of the later type maintains 14 arc lamps through about 400 yards of leads at a speed of 614 revolutions. Fig. 1 represents one of the latter machines.

The conductors from each machine are led to a common switch-board, constructed to allow any one of the machines to be in a moment put into connection with any one of the circuits. The advantages of such an arrangement are obvious. Besides this circular switch there are :—1, an ordinary two-way switch for throwing the current, without breaking circuit, into the ammeter for measurement; 2, a solid and cheap form of copper "test plug," by the withdrawal of which an accidental or premature closing of the circuit is avoided; and 3, a water-switch, designed to break or close the circuit gradually when the machine is running at a high speed This gradual

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action relieves the insulation from the strain to which it would otherwise be subjected by the extra current.

The current meter, which is common to the circuits, is of an altogether novel construction. The form is that of an ordinary flat coil galvanometer, the directive action of whose coils is intensified by the introduction into them of soft-iron cores. Between the poles of this electro-magnet rotates a soft-iron armature against the tension of a spiral spring. This armature carries an indicator needle, which moves over a graduated dial. The shape given to the poles of the electro-magnet produces equal deflections for equal increments of current. The readings, unlike those of instruments depending upon the action of a permanent magnet, are constant, and the armature is sensitive to extremely small variations of current. As constructed for arc circuits these meters indicate distinctly variations of one-tenth of an ampere. The iron cores are made to slide in

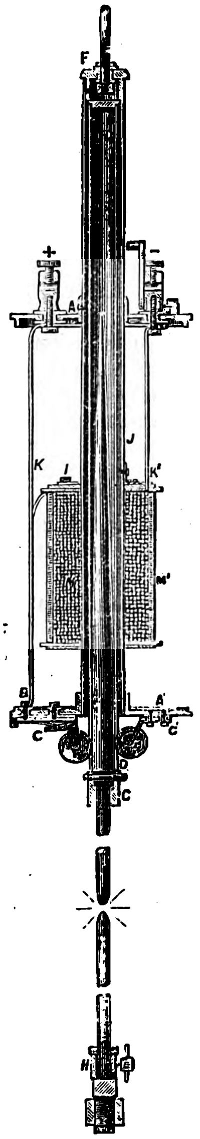

Fig. 6.

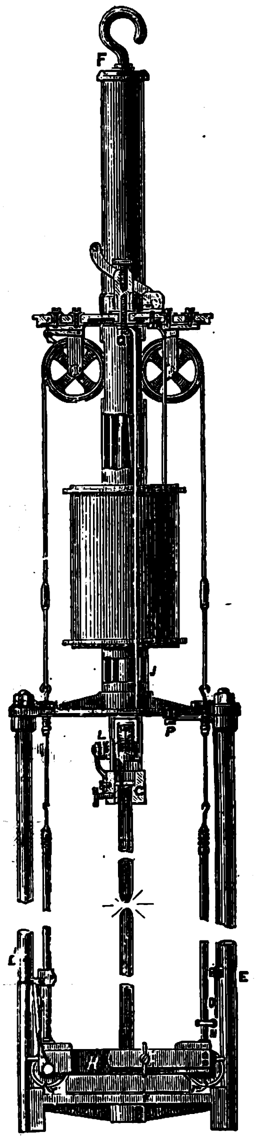

Fig. 7.

the coils, and they are adjustable with respect to their distance from the armature. The needle is dead-beat. The company's voltmeter differs from this instrument only in the winding. A "touch" is added to give security in ignorant hands. Figs. 2 and 3 represent the current meter.

Safety cut-outs or fuses are now a necessary part of an electric lighting circuit. Those of the Pilsen Company possess features which render them both convenient and certain in action. They consist essentially of a group of lead rods held in place by the pressure of a spring against the brass socket into which their ends are set. This snap action not only insures good contact, but allows the fusible rods to be removed or replaced by others when destroyed by the current in a few seconds and with the greatest ease. The arrangement permits also the use of a varied combination of fuses, of different areas, through which it is easy to arrive at the exact sectional area of lead required. A large number of these cut-outs are used at the Bethnal Green Museum lighting installation of this company, one in each main circuit, secondary circuit, and branch, in conformity with the stringent requirements of Mr. Musgrave Heaphy, on behalf of the fire insurance offices. Figs. 4 and 5 represent this safety fuse.

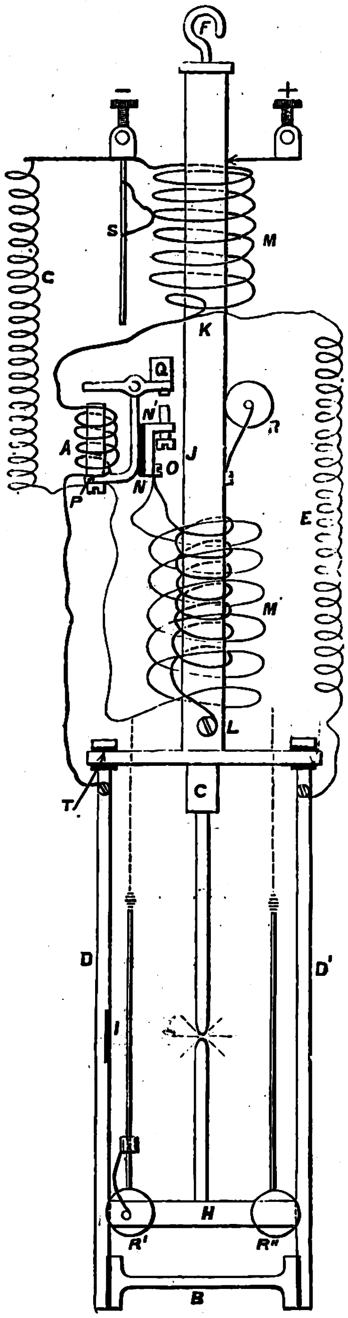

Fig. 8.

The west gallery, in which are the principal exhibits of machinery in motion, is lighted by 28 Pilsen arc lamps of 2,000 candle-power nominal, hung in two parallel rows, one on each side of the gallery. The effect is striking. This arrangement shows to advantage the steadiness of the Pilsen lamp, for an observer stationed at one end of the gallery has the whole installation in view, and the slightest flickering in any one of these numerous foci of light would become apparent. These lamps are of the common type known as P^1, the characteristic features of which are the biconical solenoid core and "tandem" coils. Near the machines is exhibited, for inspection of the working parts, another type known as P^3, having two conical cores and parallel coils. A third type, P^2, is also here

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exhibited. In this lamp there is but one spool, on which are wound both the main and the shunt coils, within which moves a single tapered core. It is claimed for this lamp that it possesses the steadiness of feed distinctive of the other types of Pilsen lamps, while its moving parts are so few that derangement is, with reasonable care, hardly possible. Figs. 6 and 7 show a lamp of the P^2 type. Fig. 8 shows the details of the lamp connections and coils.

The east central courts are lighted by 350 improved incandescent lamps of 20 candle-power actual. These take a current of 1·08 ampere, with an electromotive force of 44 volts. "This," says a contemporary, "is a very remarkable result, inasmuch as it indicates the highest efficiency yet reached in incandescent lamps." The lamps are distributed singly over the French and the Swiss courts, whereby a better diffusion of the light is obtained than by the method of grouping commonly adopted. This is another instance of care, knowledge, and sound judgment—everywhere visible in this installation—brought to bear on the difficulties encountered by this system of illumination. The Pilsen Company have here equalled, if they have not surpassed, their achievement at the Bethnal Green Museum.

THE THEORY OF THE DYNAMO-ELECTRIC MACHINE.*

BY PROFESSOR J. FITZGERALD.†

The point which I was led to call attention to frequently some years ago, and which has been investigated and experi mented upon by several, is this: Taking a coil in which the current is being started from there to there (*a* to *b*, Fig. 13); the current is going in this direction (small arrow) and the

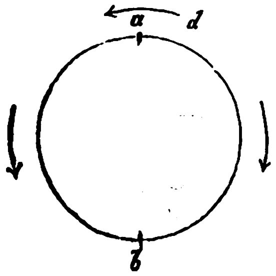

Fig. 13.

ring is turned in that direction (large arrow). When the coil was at that side (*d*) the current was running down through it in that direction (arrow); as soon as the current passes across the brush at *b* it is reversed, the current passing off. Consequently the current, which was at one time running in one direction, is reversed so as to cause the current to be running in the opposite direction. That in itself necessitates no loss of energy. The work that is to be done in stopping the current and turning it in an opposite direction does not in itself involve any loss of energy, if energy in stopping the current could be utilised in starting it again. If you could use the energy which is necessary to stop the current to start a fresh current in the opposite direction, there would not be necessarily any loss of energy in your arrangement; but what I want to call attention to is this, that in general a coil is short-circuited when it is passing from one of these positions to the other across the brushes, and consequently the energy in stopping is used in sending sudden and short currents through itself. There is in general a circuit through the coil, which is in short a short circuit in itself, and the energy of the coil which goes out in stopping is not used in starting the current in the opposite direction. Therefore you have lost the energy of the coil due to its own induction through a short circuit.

The loss of energy due to this cause for this coil will be proportional to the induction and the square of the current passing through it. If M is the induction of each coil, and C the current passing through it, M C 2 is the loss of energy due to the self-induction of the coil being wasted on the local current. This will be on each coil; hence, if N were the number of coils that were passed per second, M N C 2 would be the loss per second owing to this fact. This can be put into another form by substituting for M N the terms of the self-induction of the unit of length of the ring. If V is the velocity of the edge of the ring, and L is the self-induction per unit of length on the ring, then necessarily V L = M N; and V L C 2 will represent the loss of power owing to the self-induction of the coils. For a given ring it varies directly as the linear velocity of the ring. It was a very difficult thing to make experiment upon this effect as to whether there was any loss of power due to the self-induction of the ring. The term V L is in the nature of a small resistance which we may call R, so that the loss may be written R C 2. This is a resistance of the machine due to its velocity, and is proportional to the linear velocity and the self-induction per unit of length. The resistance of the ring is easy to obtain by rotating the ring under the action of the earth's magnetic force. One great difficulty was to get an arrangement in which there should be no reaction between the magnetic field and the ring itself. Field magnets were therefore used instead of the magnetic force of the earth, and consequently there could be no reaction from induced magnetism in the earth owing to the magnetisation of the ring. It was therefore assumed that the initial magnetic field was constant. That is the difficulty—to determine the reaction between the magnetism of the ring, and the induction which would be occasioned on the field magnets. A number of experiments were tried, and it was found that as far as the experiments went there was an increase of resistance owing to an increase of velocities, and that it was approximately proportional to the increase of velocity, and that it was approximately equal to what it was calculated it should be. It was found that the increase of resistance was a little larger than this amount; but it is almost impossible when turning a Gramme ring rapidly to prevent the jumping of the brush upon the commutator. The result of the experiments, however, led to the conclusion that the increase of resistance was to be calculated upon, and that there was a reason for not running dynamos any faster than a certain amount; that there was a certain velocity which it was well to not drive them at, because this internal resistance varied as the linear velocity of the ring. You can get over this resistance due to self-induction by constructing what are called unipolar dynamos.

First of all I may say something of the effect which Professor Rowland called your attention to—the effect of size upon this apparatus. In the first place the angular velocity is inversely as the square of the linear dimensions. Therefore the linear velocity will vary inversely as the linear dimensions. Consequently the effect due to this linear velocity would be less in the larger machines, not more than half that of a machine of half the size.

The effect of the self-induction per unit of length of the ring will be independent of the size of the machine. For the coefficient of self-induction is in general proportional to the linear dimensions of the system. The coefficient of self-induction is in general of the dimensions of a line, and therefore the self-induction of a unit per length will be independent of the dimensions of the system. Consequently you will get this: the increase of resistance is inversely proportional to the linear dimensions. Inasmuch as the increase of resistance will be inversely proportional to the linear dimensions, and inasmuch as the current varies as the linear dimensions, you have that the loss of power will be directly proportional to the linear dimensions.

The whole power is directly proportional to the linear dimensions, so that the proportion of the power lost to the whole power will be constant and independent of the size of the machine.

It is possible by constructing what are called unipolar dynamos to get over this loss owing to the self-induction. For instance, take the simplest case of Faraday's experiment with a magnet rotating. In that case there is evidently no sudden change in the current. The current is gradually diminished. There is no sudden alteration in the current; it is a uniform action, and consequently there will be no loss in this case so

* A Paper read at the Congress of Electricians at Philadelphia.

† In continuation of Professor Rowland's Paper on this subject in our last issue.

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far as I can see owing to the increased velocity at which it goes. You will have here the self-induction of the current diminishing, and helping to increase the current at some other point. Hence, there will be no loss due to the stopping and starting. Some people find difficulty in understanding how there can be no loss in an opposing force. It is the case of a crank running upon a wheel, there is no loss owing to the reciprocation of the crank, the mechanical force that is required to start it at one end being given out at the other end. But in this case it is like a bad crank, which joggles upon its bearings; and in this case there is a loss by the reciprocation of the action.

In this case we have the loss due to short breaks, and in that case there would be a loss owing to the increased pressure of the crank on the bearings. In every check of the crank there will be a loss, and hence in this case there will be loss, owing to the fact that you have to change the current from one direction to the other. But in this case of the unipolar machine it is like a crank axle in which the motion goes on uniformly without any unnecessary joggle round and round. Therefore there is no loss due to self-induction.

It is possible, also, to arrange Gramme armatures in such a way that there would be no loss owing to this cause, by arranging them so that there shall be a number of different brushes and the current divided between these different brushes. The easiest way in which I can explain this is by taking the case of two Siemens armatures, the current being divided between them, part to one and part to another. Now, it is evident that it is possible to arrange the brushes in a certain position so that the brushes themselves shall make a contact in this armature at the time when the electromotive force is exactly the same as the electromotive force that is required to be sustained between those two wires, whereby the potential at the ends of the armature is the same as at the ends of the two brushes, the potential of the brushes being kept up while this contact is being made at the armature; so that you can make the contact with the brushes when the potential of the brushes is the same as the potential of the armature, and therefore there will be no tendency for the current to start or stop at that time through the armature, and therefore it must start gradually. On the other hand, it is evidently possible to arrange the electromotive force so that at the instant of turning it shall be able to stop the current in this direction, but not to drive the current in the opposite direction; thus driving the current in this direction during a part of the revolution and in this direction during another part. During the intervening time, it is evident that there will be some instant in which there is no current running in this armature. If that is the moment which is chosen for breaking the current there will be no spark owing to the self-induction at that time. So that by making the contact between the brushes and the corresponding commutator at the time when the potential of the brushes is the same as the end of the armature, and when there is no current running in that coil, you will necessarily have a machine in which there is no loss in this way owing to the sudden breaking and stopping of the current.

I would just like to say something in connection with the question that Professor Rowland mentioned upon another point, and that is, that in a large dynamo you have got an obvious advantage; that it is possible to make the clearance very much less in proportion than in the small dynamo.

You can make the angular distance between the armature and the poles very much smaller in proportion in the large dynamo than in the small one, owing to the possibility of making the clearance much less. Another advantage in the large dynamo, on account of the electromotive force being nearly the same in the two dynamos, you may make the proportion between the area involved in the insulation and the area of the conductor smaller in the large dynamo than in the smaller one. It would not be necessary to make the area of this armature proportional to the linear dimension, consequently you can have a much larger conductor in proportion in the large than in the small dynamo; so that that is an additional advantage you can have in the large dynamo.

With reference to the centrifugal force, while I was waiting I worked out a little point that I would like to draw attention to, and it was with reference to the Gramme ring. I have come to the conclusion that the tension of the material and the wires per unit of area will vary directly as the square of the linear velocity; and that therefore the velocity being inversely proportional to the linear dimensions, the tension per unit of area will vary inversely as the square of the linear dimensions; and that therefore you may drive the larger Gramme ring considerably faster than you could the smaller without any danger of its flying to pieces. I think the tension of the ring is exactly proportional to the square of the linear velocity. But I am not sure. I am sorry that this is all I can give you upon the subject.

ON THE PERMANENT TEMPERATURE OF CONDUCTORS.*

(CONCLUDED FROM PAGE 540.)

I have also made some preliminary experiments on copper wires of various diameters without solid covering, cooling in air and in vacuum. In commencing these experiments I used as a formula for controlling my results an expression derived as follows:—

A current passing through a given wire produces heat of which the amount, according to the well-known formula of Joule, is given by—

$$H = C^2 R/J \quad . \; . \; . \; . \; . \; . \quad (1)$$

where C is the current, R the resistance, J Joule's equivalent, and H the quantity of heat produced per second, each being reckoned in C.-G.-S. units. Lel l be the length of the wire experimented on, and d its diameter; and let σ_t be the specific resistance of the substance at the temperature $t°$. Then—

$$R = \frac{\sigma_t \times l}{\frac{1}{4}\pi d^2} = \frac{4\sigma_t l}{\pi\, d^2}$$

Hence from (1)

$$H = \frac{C^2}{J} \times \frac{4\,\sigma_t\, l}{\pi\, d^2} \quad . \; . \; . \; . \; . \; . \quad (2)$$

Now let H′ be the quantity of heat lost by the wire by emission from the surface; let e be the emissivity; and let θ be the temperature of the surroundings within which the wire is cooling.

Then

$$H' = \pi\, d\, l \, . \, e\,(t - \theta) \quad . \; . \; . \; . \; . \quad (3)$$

But when a permanent temperature is attained H must equal H′, and hence we have from (2) and (3),

$$e = \frac{4\, C^2\, \sigma_t}{J\pi^2 d^3 (t - \theta)} \quad . \; . \; . \; . \; . \; . \quad (4)$$

Experiments have been made by Mr. D. Macfarlane (*Proc.* Roy. Soc., 1872, p. 93) for the purpose of determining the emissivity of surfaces in absolute measure. Mr. J. P. Nichol has also obtained results, which were communicated to the Royal Society of Edinburgh by Professor Tait, 1869-70, and which have been reduced to absolute measure by Professor Everett, "Units and Physical Constants," Chap. IX., Sec. 137.

On calculating the value of the emissivity for small copper wires by means of the formula (4) given above, I have found in every case a much greater emissivity than was obtained by these experimenters; and so far as I have been able to go up to the present the emissivity seems to increase as the diameters of the wires experimented on are diminished. Macfarlane's determinations of emissivity were made for a copper globe of 4 centims. diameter, and found to be about $\frac{1}{4000}$ of the thermal unit C.-G.-S. per square centim. per second per degree of difference of temperature for a polished surface with a little over 60° of excess of temperature, and for a blackened surface with excess of 5° or under. For round wires of small diameter I have found very much larger emissi-

* On the Permanent Temperature of Conductors through which an Electric Current is passing, and on Surface Conductivity, or Emissivity. By J. T. Bottomley. With a note by Sir William Thomson, F.R.S.

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vity than $\frac{1}{4000}$. I have obtained different values of e for wires of different sizes, varying from $\frac{1}{2000}$ with a polished wire diameter 0·83 millim., and excess of temperature 27·5° C., down to $\frac{1}{400}$ with a wire of 0·40 millim., and excess of temperature 24° C.

In order to examine the question more thoroughly, I have commenced experiments in which I am endeavouring to do away with the part of the emissivity which is due to convection and carriage of the heat by air. I have experimented to a certain extent on small wires in the nearly perfect vacuum obtainable with the mercurial pump, and I am preparing for a more complete series of experiments. It seems certain that this method of experimenting will give a very accurate way of determining the value of e in absolute measure for the surfaces of wires.

During the writing of this paper Professor Stokes has kindly reminded me of the experiments made by Mr. Crookes (*Proc.*, Roy. Soc., Vol. 31, p. 239). I find that my results, so far as they go, agree perfectly with those of Mr. Crookes, showing a decrease in the emissivity due to lowering the air pressure, this decrease being very small for a reduction down to one-half or one-third of the ordinary atmospheric pressure, but becoming very great with the almost perfect vacuum obtained with the mercurial pump.

The following table shows the emissivity of a copper wire with bright surface half a metre long, 0·40 millim. in diameter, and sealed into a glass tube, about 1·5 centim. internal diameter :—

Current Amperes.	Pressure, 760 millims.		Pressure, 380 millims.		Pressure, 180 millims.		Very high vacuum pump worked continuously.	
	$t-\theta$	e	$t-\theta$	e	$t-\theta$	e	$t-\theta$	e
	deg.		deg.		deg.		deg.	
1	4·7	$\frac{1}{1822}$	4·5	$\frac{1}{1784}$	5·5	$\frac{1}{2170}$	17	$\frac{1}{6443}$
2	22·5	$\frac{1}{2084}$	21·5	$\frac{1}{1996}$	23·5	$\frac{1}{2174}$	68	$\frac{1}{5620}$
3	56	$\frac{1}{2114}$	58	$\frac{1}{2180}$	55	$\frac{1}{2082}$	140 ?	$\frac{1}{4606}$ *

* Temperature probably much too low. The wire, sagging down, touched the glass tube in several points.

In the somewhat crude state of my preliminary experiments I have not considered it necessary in calculating to make any allowance for heat lost at the ends of my wires by conduction to the masses of metal to which they were soldered. The following appended note, however, contains an investigation of the correction which, in future experiments, it will be necessary to apply.

Note by Sir W. Thomson.

To estimate effect of conduction of heat from the tested wire through its ends, suppose the ends to be kept at the atmospheric temperature. This supposition corresponds to the greatest possible degree of the effect in question. (Adopting Fourier's notation, in the first four symbols), let v be the excess of temperature in the wire, at distance x from one end :

a, the length of the wire ;
k, its thermal conductivity ;
h, the thermal emissivity of its surface ;
g, the girth of its cross section ;
A, the area of its cross section ;
s, the specific electric resistance of its substance (C.-G.-S.);
$\frac{1}{10}$ Ac, the strength of the current (C.-G.-S.) ;
(or c, the current in amperes per square centimetre of cross section) ;
and J, Joule's equivalent multiplied by the force of gravity at Manchester (42344 × 981·34 = 41·55 centimetre-dynes), the dynamical equivalent of the thermal unit (C.-G.-S.),

we have by Fourier and Joule :

$$\frac{d}{dx}\left(k\mathrm{A}\frac{dv}{dx}\right) - g\,h\,v + \frac{c^2 s}{100\,\mathrm{J}} = 0 \quad . \quad . \quad . \quad (5)$$

Neglect now the variations of k and s with temperature, and suppose the conductor of uniform material and area and girth of cross-section throughout its length from $x=0$ to $x=a$. Equation (1) becomes—

$$\frac{d^2 v}{d\,x^2} - \frac{g\,h}{k\,\mathrm{A}}v + \frac{c^2 s}{100\,\mathrm{J}\,k\,\mathrm{A}} = 0 \quad . \quad . \quad . \quad (6)$$

and its integral, fulfilling the end conditions, is—

$$v = \frac{c^2 s}{100\,\mathrm{J}\,g\,h}\left[1 - \frac{\epsilon^{-m\,x} + \epsilon^{-m\,(a-x)}}{1+\epsilon^{-m\,a}}\right] \quad . \quad . \quad (7)$$

where $$m = \sqrt{\frac{gh}{k\mathrm{A}}}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

For round wire or rod of diameter D, we have—

$$g = \pi\mathrm{D}, \text{ and } \mathrm{A} = \tfrac{1}{4}\pi\mathrm{D}^2 \quad . \quad . \quad . \quad . \quad (9)$$

whence $$m = \sqrt{\frac{4h}{k\mathrm{D}}}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

For copper we have $k = {\cdot}91$ (Angström).

Now put $$h = \frac{1}{n \times 1000}$$

where n might be about 4 for the ranges of temperature in Mr. Bottomley's experiments, if we could judge from Macfarlane's experiments on the cooling of a globe of copper of 4 centims. diameter; and in the wires experimented on by Mr. Bottomley, D = 0·08. Hence for these wires—

$$m = \sqrt{\frac{4/n}{{\cdot}91 \,.\, 80}} = \frac{1}{8{\cdot}5}\sqrt{4/n} \quad . \quad . \quad . \quad . \quad (11)$$

Hence if $n=4$, $m = \frac{1}{8{\cdot}5}$. But Mr. Bottomley's experiments show n to be more nearly $=1$, and to be actually <1 for wires of somewhat less diameter than ·08. Hence we have, as a practical rough approximation, $m = \frac{1}{4}$; and (7) becomes

$$v = \frac{c^2 s}{100\pi\,\mathrm{D}h\,\mathrm{J}}\left[1 - \frac{\epsilon^{-\frac{x}{4}} + \epsilon^{-\frac{a-x}{4}}}{1+\epsilon^{-\frac{a}{4}}}\right] \quad . \quad . \quad . \quad (12)$$

In Mr. Bottomley's experiments $a = 50$, and therefore

$$\epsilon^{-\frac{a}{4}} = 1/\epsilon^{-12{\cdot}5} = 1/268000,$$

which may be neglected ; and we have

$$v = \frac{c^2 s}{100\,\pi\,\mathrm{D}\,h\,\mathrm{J}}\left[1 - \epsilon^{-\frac{x}{4}} - \epsilon^{-\frac{50-x}{4}}\right] \quad . \quad . \quad (13)$$

which shows that at a distance of 4 centims. from either end the temperature is less than in the middle by ϵ^{-1}, that is 1/2·7 of the middle temperature ; at 8 centims. it is less by 1/7·4 ; and at 12 centims. it is less by 1/20. Thus we see that the cooling by the ends is very sensible through a quarter of the length from either end ; and must be carefully allowed for by aid of (7), unless lengths of considerably more than half a metre are taken. But we also see that the results stated in this preliminary paper are not sensibly affected, or hardly sensibly affected, by cooling from the ends.

LONG-DISTANCE TELEPHONING IN BELGIUM.

As stated in a note, bearing the above title, in our last week's number, the Van Rysselberghe system has now been applied to the telegraph wires between Brussels and Antwerp, thus permitting of oral communications being made between the subscribers to the exchanges in both cities, as well as by the general public, without interfering with telegraphic messages. We have been favoured with extracts from the *Moniteur Belge*, the official journal of the Belgian kingdom, containing the report on the subject to the King, his Majesty's decree on the subject, and the regulations issued by the Postal and Telegraphic Department of the Ministry of Railways, Posts, and Telegraphs, translations of which we give below :—

REPORT TO THE KING.

SIRE,—Art. 1 of the law of 11th June, 1883, authorises the Government to undertake itself, or to concede to others, the laying and working of telephone lines. As a first application of this law, the new service of intercommunication has been conceded in Brussels, Antwerp, Ghent, Liége, Verviers, Charleroi, Mons, La Louvière, Louvain, and the sur-

rounding communes for a distance of 10 kilometres (6 miles). Most of these local systems are now in regular operation, and have already been considerably extended. Circumscribed by the limits of the concessions, the telephone does not yield all the advantages which can be derived from it by the public and the various branches of national industry. Telephonic communication should be rendered possible, within the kingdom, between important centres, and by and by with neighbouring countries. Placing the systems conceded in intercommunication is one step in this direction. The Government should retain the working of long distance telephoning, which might to a certain extent affect the revenue derived from telegraphic messages. It was, therefore, especially incumbent on the Government to establish conducting wires for connecting local enterprises. But the laying down of special telephone conductors would have entailed such expense and delay as to defer the realisation of this improvement. Thanks to the remarkable inventions of a young Belgium *savan*, M. Van Rysselberghe, existing telegraph lines may be utilised, at slight expense, for transmitting oral communications without any interruption of telegraphic messages. In presence of this result, my department may legitimately take credit for having considerably aided the investigations and preliminary trials of the inventor. The carrying out of the transformation, undertaken by the Administration at the beginning of the present year, being now completed, and the main lines of the State connected with the central stations of the concessions, it only remains to fix, for regular working, the tariffs and regulations for telephonic messages exchanged between any two points of Belgian territory over the State lines. Such is the object of the decree which I have the honour of submitting to your Majesty.

The Minister of Railways, Posts, and Telegraphs,

J. VANDENPEERENBOOM.

ROYAL DECREE.

Leopold II., King of the Belgians,

To all present and to come, greeting.

In presence of the law of 11th June, 1883, with reference to the laying and working of telephone lines, and especially Article II., which extends to telephonic messages the provisions of the law of 1st March, 1851 ;

In presence of the law of 26th December, 1883, proroguing the law of 1st March, 1851 ;

Considering that it is advisable to regulate the tariffs and regulations as to long-distance telephonic communications between the systems established and worked by virtue of Article I. of the law of 11th June, 1883, aforesaid ;

On the proposition of Our Minister of Railways, Posts, and Telegraphs,

We have decreed and decree:—

Art. 1. Telephonic messages exchanged between any two points of Belgian territory by means of local systems and the State lines are subjected to the following fees:—

During the day:

One franc (10d.) for an integral period of five minutes' actual conversation ; 1fr. 50c. (1s. 3d.) for an integral period of more than five and not more than ten minutes' actual conversation.

The fees during the night (from 9 p.m. to 7 a.m.) are double those during the day.

This tariff is applicable from the moment direct communication is established between the public or private stations that are called.

The duration of actual conversation may not exceed ten minutes.

Art. 2. The fees are payable by the person who has applied for communication to be established.

The subscribers to telephone exchanges are responsible for the payment of the fees for all messages transmitted by their respective wires.

In offices open to the public, fees are always payable in advance.

Art. 3. The messages of telegraph officials, the *concessionnaires* of telephone exchanges in communication and the agents of *concessionnaires* specially authorised are exempt from the payment of fees, when the messages are connected with the service of long-distance telephoning.

But *concessionnaires* and their agents can only correspond with one another gratuitously from one central station to another.

Art. 4. Our Minister of Railways, Posts, and Telegraphs is charged with the execution of the present decree; and he will fix the date of the commencement of the service.

Given at Brussels, 10th October, 1884,

LEOPOLD.

By the King,
The Minister of Railways, Posts, and Telegraphs,
J. Vandenpeerenboom.

REGULATIONS.

The Royal decree of the 10th October fixes the rates for telephonic communications, transmitted at long distances between the telephone exchanges established in the principal towns and centres of the country. The service will commence on the 20th October between the conceded systems of Brussels and Antwerp. Conversations may be carried on, either between subscribers' stations, or between public telephone offices and subscribers' stations, or, again, between public telephone offices. The rates are applicable, without distinction, to the communications exchanged by means of local exchange subscribers' instruments, and those of persons who make application to send communications in public offices. These rates are:— During the day, from seven o'clock in the morning till nine at night, 1 franc (10d.) for five minutes' conversation or less ; and 1 franc 50 cents. (1s. 3d.) for a conversation of more than five minutes and not exceeding ten minutes. During the night, from nine o'clock in the evening to seven in the morning, the fees are raised respectively to two and three francs (1s. 8d. and 2s. 6d.). No additional charge can be made to non-subscribers. The communications are made in the order of application. The duration of calling subscribers' stations or public offices is limited to one minute by day and five minutes by night. The time is counted from the moment communication is established between the public or private stations called. Consequently, calls not followed up by conversation will not be charged. The duration of actual conversation may not exceed 10 minutes. At the expiration of this period communication will be interrupted, as a matter of course. Those who have not finished their conversation can only obtain renewed communication if there are no other applications. In this latter case, the application for renewed communication will take its turn with others. In either case the conversation will be subject to the application of the tariff given above, just as if there were a distinct application. The fee is due by the person who *applies* for the communication, and is collected, for the Administration, by the *concessionnaire* of the local exchange. The subscribers of telephone exchanges are responsible to the *concessionnaire* for the payment of fees for *all* the conversations applied for by means of the instruments at their command. They may, however, free themselves from this responsibility by giving notice in writing of renouncing the use of these instruments for calling for long-distance telephonic communication ; and the *concessionnaire* will acknowledge by letter the receipt of this declaration. Subscribers are bound to pay the amount of the fees within three days following the despatch of the account prepared by the *concessionnaire*, after which period this functionary may claim payment through the post at the subscriber's expense. In the event of absolute refusal to pay the fees, the affording of future long-distance telephonic communication may be made dependent on the previous payment of the back fees due, without prejudice to recovery thereof at law by the *concessionnaire*. In the telephone offices open to the public, the previous payment of the maximum fees (1fr. 50c. or 2fr., as the case may be) is always required. They are, however, returned wholly or partially, according as the communication applied for shall not have been established, or only for five minutes at the outside. The central offices of the *concessionnaires* are open day and night for long-distance telephoning. The offices accessible to the public are constantly open, including Sundays and holidays:—

At Brussels:—1. At the Bourse (entrance in the Rue de la Bourse) from 9 a.m. to 7 p.m.; 2. Place des Palais (Kiosque at the entrance to the Parc) from 9 a.m. to 7 p.m.

At Antwerp:—1. At the Eastern Station (Salle des Pas Perdus), from 8 a.m. to 8.30 p.m.; 2. Chaussée de Malines, near the "Harmonie" (Tramway Station), from 9 a.m. to 7 p.m.; 3. Place de la Commune (Tramway Station), from 9 a.m. to 7 p.m.; 4. Avenue de l'Industrie, near the National Bank (Tramway Station), from 9 a.m. to 7 p.m.; 5. At the Bourse (ground floor), from noon to 3 o'clock, provisionally.

A general list of the subscribers to the local exchanges in communication lies at the disposal of the public in these offices.

Communications applied for to be sent *to* a public office are only made if, by previous arrangement between the parties desiring to hold conversation, the *telephonee* be present at that office. This understanding may be arrived at by the ordinary means, such as a letter, telegram, &c.

It is expressly recommended, in the interest of those holding conversation:—

A. To place themselves opposite and only at a few centimetres' distance from the vibrating plate of the microphonic transmitting instrument.

B. To speak slowly without forcing the voice, and to articulate clearly.

As the words have to be transmitted to a much greater distance than the limits of the local exchange, speaking to one side of the transmitting instrument, turning the back to it, or standing at any considerable distance therefrom, must be carefully avoided.

The Government and the *concessionnaires* of the local exchanges are exempt from all responsibility connected with the service of long-distance telephoning.

ANCIENT TELEGRAPHS.

At the Wigan Free Library, on 17th October, Mr. Alderman Bailey delivered the first of the present winter lectures, the subject being "Ancient Telegraphs, from the Fall of Troy to the Battle of Waterloo." The lecturer said:—

Talking by means of signs and without the tongue being used is called telegraphing. The word "telegraph" is derived from two Greek words, which signify "to write" and "at a distance." We are told by Lubbock and other writers of the history of civilisation that many savage tribes, by reason of their poverty of word language, are compelled to carry on a conversation by signs. Some have thought that certain of these tribes are entirely without language, but this seems extremely improbable. The statement may have arisen from the fact that in all countries inhabited by savages the number of languages is very great, and hence there is a great advantage in being able to communicate by signs. James, the American traveller in the Rocky Mountains, mentions that several tribes under the influence of one great chieftain were totally ignorant of each other's vocal language, insomuch as it was no uncommon occurrence to see two men of different nations sitting upon the ground and conversing freely by means of the language of signs. Fisher, another traveller among the American Indians, mentions a language of signs, however, by which all nations and traders can understand one another, and they always make these signs when communicating among themselves. The men, when thus talking together, sit cross-legged like Turks and communicate with each other at a speed and with a

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definiteness which would even be understood by a deaf man. For instance, Fisher says, "I meet an Indian, and wish to ask him if he has seen six waggons, drawn by horned cattle, with three Mexican and three American teamsters and a man mounted on horseback. I make these signs:—I point 'you;' then to his eyes, 'see.' Then hold up all all my fingers on the right hand and the forefinger on the left, meaning 'six.' Then I make two circles by bringing the ends of thumbs and forefingers together, and holding my two hands out, move my wrist in such a way as to indicate waggon wheels revolving, meaning 'waggons.' Then, by making an upward motion with each hand from both sides of my head, I indicate horns, signifying 'horned cattle.' Then, by first holding up three fingers and extending my right hand below my lower lip and moving it downwards, stopping it midway down the chest, I indicate 'beard,' signifying 'Mexican.' And by this way and by other similar signs and motions I ask the Indian, 'You see six waggons, horned cattle, three Mexicans, three Americans, and one man on horseback.' If he holds up his forefinger and lowers it quickly, as if he was pointing it at some object on the ground, he means 'yes.' If he moves it from side to side —on the principle that people sometimes move their head from side to side—he means 'no.'" Fisher says it takes about the same time to make these signs that it would take if you asked the question verbally. The bushmen of South Africa, we are informed by another traveller, intersperse their language with so many signs that they are perfectly unintelligible in the dark; and when they want to converse at night they are compelled to gather round their camp fires. The celebrated traveller, Burton, says of a tribe of North American Indians, who possess so scanty a vocabulary that they cannot talk in the dark, that to make a stranger understand them they must always repair to the camp fire for a "pow-wow." For purposes of war, methods of communicating from distant places have been used in all historic times, varying very little in character, and distinguished by more or less ingenuity. Bells, torches, flags, and symbols have been used for telegraphing from the earliest known periods. Probably the earliest record of such in the Old Testament is in the 6th chapter of Jeremiah: "O, ye children of Benjamin, gather to flee out of the midst of Jerusalem, and blow the trumpet in Tekoa, and set up a sign of fire in Bethacarem, for evil appeareth out of the north and great destruction." The Egyptians had signals to indicate the rank of important officers of State, many of which signals have been discovered in the excavations among the ruins of their great temples and monuments, and in the carving upon their sculptures. We are told that the banner of Benjamin, in the time of Moses, had on it a wolf, whilst the other tribes also had their emblems. The Lord, it is said, spoke to Moses and Aaron, and ordered that "every man of the children of Israel shall pitch by his own standard, with the ensign of their father's house." Among the Greeks, the Athenians had an owl, and the Thebans a sphinx upon their banners and standards, and we are told that by using these emblems and signs in a manner understood by the various companies of soldiers in war, the standard bearers were enabled to telegraph such orders as "advance" and "retreat," and to control other important military manœuvres. The use of these emblems in indicating the position of companies and regiments, in guiding friends and in warning foes, was of as much advantage to the soldiers in the old days as the numbering of the doors of the houses in our streets is to us in these later times. Indeed, this use of emblems, not only among the ancient Greeks and Romans, and even the Egyptians, but down to our own days, has given rise to the art or science of heraldry. In this way were the barons and knights of old as well as the commanders of famous legions enabled to emblazon various devices on their coats of arms, many of which we still see displayed by those who are proud of their family blood, and of what stock they claim to belong. On some occasions the device would be carefully prepared and thought out; in other cases the symbol would be something at hand which had been seized in an emergency and lifted up as a rallying point for the people, and afterwards adopted from the attachment which would cling to it as an object identified with patriotic deeds. One of this sort must have been the Persian blacksmith's apron, which for many years, until the Mahommedan conquest, was the standard around which the people rallied to resist the invader. Some person may remember how Longfellow, in his poem, "The Norman Baron," describes in fine sentences the freeing of his serfs:—

> "Every vassal of his banner,
> Every serf born to his manor,
> All those wronged and wretched creatures
> By his hand were freed again."

Beacon fires and torches by night and pillars of smoke by day seem to have been used both by most civilised and savage peoples in all ages for transmitting messages. Homer, describing "the lambent flame" which shone round the head of Achilles and spread its lustre all about, speaks by way of comparison of the signals made in the besieged cities, "the clouds of smoke by day and the bright fires by night, which call on neighbouring cities for assistance." Various Roman writers mention different methods of communicating by means of torches. Julius Africanus says "substances were made use of in making the torch fires," and some writers have thought that these fires and torches may have been of different colours, thus enabling the Roman general to ring the changes in spelling words and in sending messages. Probably one of the most ingenious telegraphs of ancient times was one used by the Greeks. The Greeks had a very good method of indicating the time of day by a clepsydra, or water clock, the indicating process being effected by means of a float in a vessel containing water which slowly subsided through a small hole in the bottom. The height of the float in the water told the time of day. Instead of winding up the clock, as we do, all that was necessary to start it again was to fill the vessel up with water, and let it resume running. Indeed, the idea was the same as in the old-fashioned hour glass; only instead of sand being used, observations were made by the fluctuations of the water. I will now endeavour to describe one of these clocks, a model of which we have on the table here. You will be kind enough to imagine two of these water clocks, which have been regulated for the floats to descend at exactly the same speed. They have been made—to use a scientific term—isochronous; that is, made to keep equal time. We will imagine one of these instruments placed at night, with the sender of a message, on the top of a mountain, and another on a distant hill, say two miles away. There we have them, sender and receiver. When a message had to be sent the sender would hold his torch up. That was the signal for the receiver to prepare his instrument and set it to zero by filling up with water. The sender would hold up his torch twice. This was a signal that he had permitted his clock to start running down; that is to say, for the water to escape by means of a faucit at the bottom. The receiver, seeing this signal, would at once allow his water clock to begin running down, and so both clocks would go on doing this at the same speed. Then, when the sender held up his torch again, it was a signal to stop. The receiver would stop his instrument and look on the stem for the letter of the alphabet which the sender meant to indicate, and thus, by repeating the operation the needful number of times, a message could spelled out with great facility. It is very remarkable that this ingenious water clock telegraph of the ancients, with a slight modification which I will explain later on, was similar to one of the first alphabetical telegraphs in this country, introduced by Mr. (afterwards Sir) Francis Ronalds about the time of the battle of Waterloo. Instead of using water clocks, Mr. Ronalds permitted two clocks with weights and wheels to run down; having, indeed, in his mind exactly the idea which the old Greeks had over 2,000 years ago. A celebrated Greek writer of tragedies, Æschylus, who lived over 500 years before Christ, wrote a tragedy in which he gave an account of the fall of Troy, an event which occurred—if it really did occur at all—from one to two thousand years before his time. In this work he describes the famous city as having been besieged, according to the accepted version, for ten long years. He tells of the watchman who had been stationed by Queen Clytemnestra to watch the signal station to which had to be sent the news of the fall of the doomed city. The watchman grumbles, bewailing his fate that through the long years the gods give him no deliverance from his vigil. He laments that he has had to crouch with his elbows on the roof like a dog, contemplating the hosts of nightly stars and the bright potentates that bear winter and summer to mortals, conspicuous in the heavens. He dreams, and says that even when he is at rest he starts with fright and fear, because of his monotonous occupation. He cannot even sing or whistle, he is in such a sad way; not only because of his melancholy work, but because his queen bedecks her couch with tears for her lord who comes not. But at last he sees the torchlight on the far-off mountain top, and exclaims, "But now may there be a happy release from all my toils, as the fire of joyous tidings pierces through the gloom. Oh! hail, thou lamp of light—thou that displays the light like the day and the marshalling of many dances in Argos, on account of this joyful event. Oh, oh, I will give a signal distinctly to the wife of Agamemnon, that she having arisen with all speed from her couch may raise aloud a joyous shout in welcome to this beacon. If indeed, the city of Ilion is taken, as the beacon light proclaims, I myself will dance a prelude. May it then befall me to grasp with this hand of mine the friendly hand of my king on his arrival at this palace." Clytemnestra receives the intelligence with gladness, and in expressing her delight the chorus of the Greek tragedy tell her it is foolish for her to believe in soothsayers and witchcraft, and that it is just possible she may be the sport of visions and dreams. She retorts upon them:—"I would not take the opinion of my soul when sunk in slumber." She is no young girl, she says, to be mocked by foolish rumour, and adds that the messenger has given her true intelligence, because she had arranged her signals in a proper manner. The city, she tells the chorus, was sacked the day before. The chorus ask, "But what messenger could come with such speed!" The Queen replies, "Vulcan sent forth a brilliant gleam from Ida, and beacon despatched beacon of courier fire hitherward. Ida, first to the Hermæan promontory of Lemon, and third in order Athos, Mount of Jove, received the great torch from the Isle, and passing o'er, saw as to ridge the sea, the might of the flame as it joyously travelled, the pine-torch transmitting its gold-gleaming splendour, like a sun, to the watch towers of Macistria. And the watchman, ever ready to do his duty, sent the light of the beacon coming from afar to the streams of the Euripus, gives signal to the watchmen of Messapius, and they lighted a flame in turn and sent the tidings onward, having kindled with fire a pile of withered heath, and the flame in its strength not yet at all bedimmed bounding over the plain of Asopus, like the bright moon, to the crag of Cithæron, aroused another relay of the courier fire, and the watch refused not the fire that was sent thus from afar, lighting a still larger pile, which darted across the lake Gorgopis, and having reached the mount and lighting up in increasing strength, they sent on the mighty beard of flame so that it glared beyond the headland that looks down upon the Saronic frith, and hence it darted down to the Arachnæan height, and therefrom to this roof here darts the light, no new descendant of the fire of Ida. Such were my commands to the bearers of the torches, fulfilled by succession from one to another. Such proof and signal do I tell thee of my husband's victory at Troy." It is obvious that the news of an invasion, or of a victory, or any special intelligence that would be well known to all the people along the country side, could easily be sent by means of torches and bonfires from mountain top to mountain top. But the system of spelling and using words would indicate greater ingenuity, and would require a trained staff to send the messages. We find, according to Sir Walter Scott, in his "Lay of the Last Minstrel," that an Act of Parliament was passed at Edinburgh, in 1455, which directed that one bale or faggot burnt at a station should be the warning that the English were advancing; that if the English were come indeed two bales must be used; and that if the enemy existed in great force, four bales must blaze side by side of each other. Gen. Fremont, when fighting

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the American Indians of California some few years ago, reported in an official despatch that whenever he appeared in the country he noticed at scattered intervals upon the mountain tops pillars of smoke in the day time, and these, he observed, were the signals of the Indians communicating to the various tribes the intelligence that the enemy was in the country. We find in the names of many places in our own country evidences of old signal stations. Taking into consideration the number of times England has been threatened with invasion by foreign foes, one may imagine that great pains would be taken to perfect a system of telegraphy that would enable our ancestors to resist the invaders. But whatever steps may have been taken, it has been with the greatest possible difficulty that I have obtained records of any particular system, except within comparatively modern times. I have made a careful examination of that portion of English history one hundred years before the battle of Bosworth Field, only to find that writers seem to have been very silent as to the method in which intelligence was conveyed. It appears that when Richard III. was making arrangements to defend the throne at which he had arrived by foul and unnatural murders, he stationed horsemen along the principal roads of the Midland Counties, and leading to the coast, at twenty miles apart. These couriers could carry information very rapidly, the system being such as to permit of a letter being taken a distance of two hundred miles in two days. For some reason which is not explained, this plan was evidently not in operation just before the battle of Bosworth Field, for we are told that, despite Richard's vigilance, the Earl of Richmond landed at Milford Haven and rapidly advanced through Wales, and the valiant Welshman, Rhys ap Thomas, who contributed so much to the success of Richmond's enterprise, ordered beacon fires to be lighted on the mountain tops, and summoned his Welsh retainers to the field. Richmond and the Welshmen and the men of Lancaster were at Shrewsbury before Richard knew of Richmond's arrival in the country. There is a poem written by a Welsh bard, who tells us of the part which Rhys ap Thomas played, and praises his heroic deeds under the standard of Richmond; and the bard tells us that not only did all the enemies of Rhys ap Thomas fear him, but that even wild Irishmen had been known to tremble in his presence. There is one bit of local history in connection with Bosworth Field that may prove of some interest to the people of Wigan. It seems that when in France, shortly before that eventful battle, Richmond had registered a vow that he would wed the Princess Elizabeth if he ever became king of England. The princess, as you will be aware, was sister to the two young princes who had been murdered by Richard in the Tower. Elizabeth was very anxious to obtain the aid of the Stanleys of Lathom—Lord Stanley and his brother, Sir John—and also the Stanleys of Manchester, all relatives. In an old ballad of the period the princess is described as giving instructions to a messenger to go through Manchester to Lathom Hall, and mind and turn at Salford Bridge. Stanley promises to come, and assures the princess through her trusty messenger that on reaching London he will stay at an inn which he does not often frequent, and her friends may know that a Stanley is there when they see an eagle's foot chalked on the door. In this connection it may be mentioned that Stanley's retainers were called "Eagle's feet men," as some others were styled "Bears and Ragged Staffs," after the devices on their masters' crests. The other day I met with a very interesting account in the "Palatine Note Book" of the origin of the names of places. It seems the town of "Ingleborough" really means the signal or fire borough, "ingle" meaning "fireplace." Then we have Inglewood, Beaconsfield, and other places, which have derived their names from the ancient use to which they were devoted as signal stations. In the north we have "Scout Star," a hill where the scouts or watchmen were stationed. A new departure in torchlight telegraphy was made in the Shetland Isles at the beginning of this century by the Rev. James Bremner, to whom the Scottish Society of Arts presented its medal for his invention. By the use of a single torch the rev. gentleman was enabled to send messages. This was done by alternately exhibiting and concealing one torch. Indeed, so far as I have been able to learn, Mr. Bremner may be considered to be the inventor of the flash light system, which, in the modified form, is now used on the vessels of the British navy, and also by our army in the field at night. It was used in the recent campaigns in Abyssinia, Afghanistan, and Egypt. This alternate exhibition and concealment of the light enables a word to be sent nearly as fast as man can write. On ships at night, instead of a torch being used, powerful lanterns are substituted. No doubt most of you are aware that the flash light telegraph is made by means of a piece of looking glass, and when the sun shines this is called the heliograph. Messages are sent by simply placing this looking glass at such an angle as to reflect the sun's rays. By means of a telescope messages have been received in this way from a station ten miles away. The Morse code of the dot and dash system is used for the flash light purposes, and by alternately exposing and concealing the looking glass by day, and the lantern by night, messages can be sent, as I have said, nearly as fast as a man can write. It seems that Mr. Bremner, the Shetland clergyman, put his plan into operation, and was enabled to communicate at night between one island and another; and he established two stations, one in Scotland and the other in Ireland, and was thus in a position to telegraph between points twenty miles apart. Probably the most exciting conditions—at any rate to the people of this country—under which the old system of telegraphing by means of torches, beacon fires, banners, and guns, occurred on that memorable night when the whole country was roused to resist the invasion of the cruel and arrogant Spaniard, now close upon 300 years ago. Spain, it must be borne in mind, was at the time of the Armada acknowledged to be the most powerful military nation in Europe, and she had earned a reputation for cruelty which placed the people of this country in real fear. The story of that eventful period is in the mind of every school boy. Then was it that every man who could bear gun or pike placed himself at the service of the Queen. Does not Macaulay tell, in brave words, of the patriotic manner in which the Lord Mayor of London answered Elizabeth's demand for 15 ships and 5,000 armed men? And has not our blood circulated all the faster as we have read the sturdy answer which the bold Englishman gave his Queen—how he begged her Majesty to accept, instead of 5,000 men, 10,000 men, and instead of 15 ships fully armed, manned, and equipped, 30 ships to defend their native land? You remember how Macaulay, in that spirit-stirring "Fragment" of his, tells how the news came to the south coast that the Armada was in sight, and how the whole afternoon and night were devoted to sending warning signals throughout the length and breadth of the country. News of "the great fleet invincible" came by "a gallant merchant ship, full sail to Plymouth Bay," and—

Forthwith a guard at every gun was placed along the wall,
The beacon blazed upon the roof of Edgcomb's lofty hall;
Many a light fishing bark put out to pry along the coast,
And with loose rein and bloody spur rode inland many a post.

* * * * * *

And swift to east, and swift to west, the warning radiance spread,
High on St. Michael's Mount it shone—it shone on Beechy Head;
Far on the deep the Spaniard saw, along each southern shire,
Cape beyond cape, in endless range, those twinkling points of fire;

* * * * * *

And broader still became the blaze, and louder still the din,
As fast, from every village round, the horse came spurring in;
And eastward straight, from wild Blackheath, the warlike errand bent,
And raised in many an ancient hall the gallant squires of Kent,
Southward from Surrey's pleasant hills flew those bright courses forth,
High on bleak Hampstead's swarthy moor they started for the north;
And on, and on, without a pause, untired they bounded still,
All night from tower to tower they sprang—they sprang from hill to hill,
Till the proud Peak unfurled the flag o'er Darwid's rocky dales;
Till like volcanoes flared and heaved the stormy hills of Wales;
Till twelve fair counties saw the blaze on Malvern's lonely height;
Till streamed in crimson on the wind the Wrekin's crest of light;
Till, broad and fierce, the star came forth on Ely's stately fane,
And tower and hamlet rose in arms o'er all the boundless plain;
Till Belvoir's lordly terraces the sign to Lincoln sent,
And Lincoln sped the message on o'er the wide Vale of Trent:
Till Skiddaw saw the fire that burned on Gaunt's embattled pile,
And the red glare on Skiddaw roused the burghers of Carlisle.

During the American revolutionary war, or War of Independence, as it is called, many different methods of signalling the approach of the enemy were used. Among the various plans was one of which this model on the table is an illustration. This telegraph consisted of a post or mast which was portable. A tub or barrel placed on the top; a movable flag on one side and a basket on a bracket near the top were used to signal with. By ringing the changes with the flag, the basket, and the barrel, and by moving the flag up and down, various signals could be sent. Altogether I believe that 50 different signals could be given by this means. We now come to the semaphore signals, which are used even to the present day, chiefly for railway purposes. Probably the most ingenious and among the first of this class of telegraphs was that invented by the brothers Chappe. It appears that this invention is due to the affection entertained by the two brothers for each other. They were placed as students at different schools, a mile and a half apart. They were inconsolable at being thus separated; and by means of pieces of wood, exposed from the back windows of each school, the brothers Chappe contrived to talk to each other. In their first system of telegraphy they arranged a code of signals which enabled them to send 192 different messages; this being done by means of instruments similar to the one I now have on the table. As the ingenious brothers became older the invention was placed before the Government and was tried just before the revolution in 1791. The people, however, looked upon the invention as only another means of increasing the power of the Government and the aristocracy. The introduction of the invention was opposed; the people destroyed the telegraph stations, and the inventors barely escaped with their lives. A second attempt shared the same fate. Again the various telegraph stations were burned to the ground. The brothers Chappe, however, continued their efforts, and in 1793 the Government adopted the system. Circumstances were favourable. The telegraph, having been adopted, was fortunate enough to communicate to Paris the news of a great French victory; and now the brothers Chappe were considered part and parcel of the glories of France. This message was transmitted from the frontier to Paris:—"Condé is taken from the enemy;" to which the Directory replied, "The army of the north deserves the gratitude of the country." These messages ran like an electric shock throughout the Convention and throughout Paris. The once-abused telegraph was now the pride of the nation, and its inventors were worshipped as public benefactors. The system invented by the brothers Chappe soon became universal on the Continent. A line was carried from Paris to Lille, and two minutes only were occupied in transmitting a word. In 1802 the system was adopted in Denmark. Shortly afterwards it was made use of by the Governments of Belgium, Sweden, and Germany. Mahomet Ali erected stations on this system from Alexandria to Cairo. The most expensive series of stations was constructed in Russia by the Emperor Nicholas. A line of towers was erected from the German frontier, through Warsaw, to St. Petersburg. This line embraced 220 stations, at each of which were six men, so that 1,320 men were employed on this route, besides those who had charge of the general administration. The erection of these towers cost the Russian Empire millions of pounds sterling. The system was only finished and got to work so comparatively recently as the year 1858; and after being in operation a very short period, it was completely superseded by the electric telegraph. The towers

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are still standing—silent monuments to the ingenuity of the past. Scarcely any description is required of this Chappe semaphore telegraph. The method of manipulating the arms was by means of levers, similar to those now in daily use on our own railways. Occasionally the system was used at night, by placing lanterns on the ends of the vanes. Men were stationed along the line of communication with telescopes, and thus, by means of known changes, various codes could be worked at great speed. In France, along the route between Toulon and Paris, a distance of 475 miles, there were 120 stations; and it is said that so complete were the instruments made that over 82,000 different signals could be sent. The Prussian system of semaphore signals—a model of which we have on the table—was introduced in the year 1782. It will be seen that this is but a modification of the French system. Forty thousand signals could be sent by this means. The English semaphore shutters, or Lowre telegraphs, were invented by Lord Murray, in 1795. The instrument, as you see here, consists of six shutters working on pivots. Sixty-four distinct signals could be sent by this system from London to Dover in ten minutes. These were placed along the coast leading to stations inland, and were in general use in this country up to the invention of the electric telegraph. Messages could only be sent in the day time by this system. It is mentioned that after one of Wellington's victories over the the French, when the news was being sent to London, the sender at the coast end began the signal with the words "Wellington defeated ——." A dense fog prevented the rest of the signal being seen, and the result was great consternation in London and a panic on the Stock Exchange. When the fog cleared up the following day the rest of the message was received, and the message then read, "Wellington defeated the French." I remember when I was a boy this system being used between Holyhead and Liverpool for sending news of the arrival of the American mail. On the vessel being sighted at Holyhead the news was sent forward right across Anglesey to Puffin Island, thence to the Great Orme's Head, thence right along the Welsh coast to Parkgate, across the mouth of the River Dee, and thence to Liverpool. For many years the intelligence sent in this old-fashioned way from Holyhead to Liverpool was sent from Liverpool to Manchester by electric telegraph. Many of the old stations on the line of route between Holyhead and Liverpool are still in existence, though their occupation has gone. I have said very little of the various naval telegraphs. Among the rude Vikings of the northern seas, signals were made with banners and by blowing trumpets and horns. In an account of the invasion of William the Norman we are told that he signalled his ships by means of trumpets. The ship of the commander of a fleet could always be found in the old tapestries and old engravings by the illustration of a trumpeter at the prow of a vessel. In the "Tales of a Wayside Inn," we have a legend of one of "the dead kings of Norway," a king who went

> "Sailing, sailing,
> Listening to the wild winds wailing
> And the dashing of the foam.
>
> * * * * * * * *
>
> 'Sound the horns,' said Olaf the King;
> And suddenly through the drifting brume
> The blare of the horns began to ring."

The old system of telegraphing from one ship to another was carried on by placing flags in various parts of the vessel, at the stern and at the masthead. This was introduced in the time of James II. Sometimes terrible mistakes were made. The pendant is a well-known flag in ships of war. Its usual length is twenty yards, while it is only four inches broad at the masthead. Its history is generally understood to have been this:—After the defeat of the English under Blake by the Dutch fleet under Van Tromp, the Dutchman carried at his masthead a broom, in token that he had "swept the seas" of all her enemies. Afterwards Blake defeated the Dutchman, whereupon the English admiral in command hoisted a long streamer from his masthead, to represent the lash of a whip and as a token that he had "whipped" his enemies off the sea. There is not sufficient time for me to explain to you the various methods of spelling by means of flags. This branch of the subject would occupy a night of itself. In the year 1801 the clumsy system of signalling in the navy was somewhat simplified by the method introduced Sir Home Popham. Admiral Nelson was requested by the Admiralty to experiment with this system and to report upon it. As every Englishman knows, just as the English vessels were in line of battle in Trafalgar Bay, Nelson signalled to the captains of his fleet, "England expects that every man will do his duty." The flags here are exact copies of those used on that memorable occasion. I am indebted to the Lords of the Admiralty for kindly permitting Messrs. Thomson and Son, Admiralty flag makers, London, acting in my behalf, to search in the records for a description of these signals. The model on the table here is one of the system invented by Sir Francis Ronalds. There are many points of similarity between it and the Greek water clock telegraph. Sir Francis recommended the use of two clocks with wheels, one at the sending and the other at the receiving station. These clocks were made to drive dials at exactly the same speed, to work isochronously. The alphabet, as you see, is painted on the dials, which revolve behind a little hole, showing only one letter at a time. The sending and receiving instruments are coupled together by means of an electric wire. Pith ball electrometers are hung in front of each dial. On the balls being extended by means of an electric current this signal would cause the receiver to allow the clock to run down. Another signal causes the clock to be stopped. The sender and receiver, starting and stopping the clocks in this way, were enabled to send and receive messages in a remarkably quick manner. This, although not the first electric telegraph, is one of the first invented that was of a workable character. The inventor communicated his ideas to the War Office soon after the battle of Waterloo, and he received an intimation from the authorities there to this effect:—"Now that the war is over telegraphs will be no longer required." The telegraphs I have endeavoured to describe are chiefly those used for the purposes of war. Even in this country it was considered by official persons that the arts of peace would not be much benefited by these quick methods of communication. It is not within the scope of the lecture this evening, nor have we time, to consider modern telegraphy. For the present it may be permitted to say that, according to Mr. W. H. Preece, an eminent authority on telegraphy, 400 words per minute can now be telegraphed along one wire, as a result of the recent improvements of duplex and quadruplex circuits in connection with automatic instruments. When the telegraph service was taken over by the Government a few years ago, 126,000 messages were sent per week. Now the weekly number is 600,000. In press work the increase is most marked, the rate in this period having risen from 5,000 words per day to nearly one million—that is to say, 340 million words of press messages have been delivered during last year. England has not a monopoly of this useful agent. All prominent countries exhibit corresponding growth. The Japanese even despatch 200 million messages a year. The telephone is another wonderful advance in telegraphy. To enable people to speak in actual words, with the accent and tone, to their friends miles away, is a splendid scientific triumph. I have endeavoured to describe the ancient methods of telegraphing, and must leave the subject at the very threshold of the electric telegraph. Lightning is now the errand boy of man, whose speed is greater than flight and sound. The future development of this useful art is in the hands of the men of science who have succeeded the old astrologers and alchemists. These men are, to use the words of Ben Johnson, "the Divine instructors who can extract the souls of all things by their art; call all the miracles of the sun into a temperate furnace, and teach dull Nature what her forces are." The electric telegraph is powerful in promoting the uses of civil life; this wonderful invention is blessed in strengthening the arts of peace, it imparts vigour to man in fighting his ancient enemies, plague, pestilence, and famine. May I say that it sings psalms to the poor, for if in any corner of this wide world thousands of miles away the crops are good and the earth is blessed with abundant food, the glad tidings are quickly proclaimed by this "Swift messenger of the Gods," even before the autumn tints proclaim that they are ready for the gatherer. This obedient servant of mankind never sleeps, it has no night, sunrise, no sunset; for the sun is always shining upon it somewhere. The merry click of the instruments seem to me like Longfellow's birds—

> Remember this: It is always morning somewhere, and above
> The awaking Continent from shore to shore,
> Somewhere the birds are singing evermore!

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Oct. 29.		Business Done Week Ending Oct. 29. Highest.	Lowest.
Anglo-American	31,	32	32	31
Do. Preferred	54,	55	54½	54
Do. Deferred	6¾,	7¼	7¼	7⅛
Brazilian Submarine	11⅛,	11⅜	11⅜	11⅛
Cuba	11,	11½	11 5-16	11⅛
Do. Preference	17,	18	—	—
Direct Spanish	3½,	4	—	—
Do. Preference	14¾,	15¼	—	—
Direct United States Cable	10,	10½	10¼	10⅛
Eastern Telegraph	11⅜,	11⅝	11 9-16	11 7-16
Do. 6 per Cent. Preference	13½,	13¾	13 9-16	—
Do. 5 per Cent. Debentures, 1899	104,	107	105½	—
Eastern Extension	11¼,	12	12	11 13-16
German Union	9¾,	10¼	—	—
Globe Telegraph and Trust	6⅞,	7⅛	7¼	7
Do. Preference	12½,	12¾	12 11-16	12½
Great Northern	13⅞,	14⅛	14	—
Indo-European	32,	33	—	—
Reuter's	7½,	8	—	—
Submarine	175,	180	179	178
West India and Panama	⅞,	1⅛	8	7¾
Do. 1st Preference	7½,	8	7	6 13-16
Western Brazilian	6¾,	7	—	—
Western Union 7 per Cent. 1st Mortgage	123,	125	—	—
Do. 6 per Cent. Sterling Bonds	100,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	5-16,	7-16	—	—
Oriental	⅛,	⅜	⅛	—
United Telephone	11¾,	12¼	12 13-16	11⅝

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1⅛,	1⅜	—	—
Do. (fully paid)	8,	8½	8⅝	8⅜
Hammond Light (£3 15s. paid)	½,	⅝	⅝	9-16
Swan	—,	—	—	—
Maxim-Weston	⅛,	¼	—	—

MISCELLANEOUS.

Telegraph Construction	34,	35	34½	34
India Rubber, Gutta Percha, and Telegraph Works	22,	23	23	22 11-16

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NOTES.

West Coast of America Telegraph Company.—The gross earnings of this company for the month ending Oct. 31st were £4,065.

Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ending 31st October amounted to £3,618.

Death.—Mr. Walter Cross, clerk in charge of the Brazilian Submarine Telegraph Company's Lisbon office, expired on the 6th of October from hœmorrhage.

Indian Postal and Telegraph Service.—The Postmaster-General of India has arrived at Berlin to study the German postal and telegraph service.

The Postmaster-General.—The public will learn with regret that Mr. Fawcett, who was attacked at Cambridge by pulmonary congestion, expired on Thursday afternoon.

Direct Spanish Telegraph Company.—The estimated traffic receipts of this company for the month of October were £1,794, against £2,115 in the corresponding period of last year.

Eastern Extension Telegraph Company.—The traffic receipts of this company, including subsidies, for the month of October amounted to £41,357, and to £39,174 in the corresponding period of 1883, showing an increase of £2,183.

Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ended 31st October were £2,934, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

Electric Light at Wycombe.—We read that on the occasion of the Prince and Princess of Wales passing through Wycombe, on their way to visit Lord and Lady Carrington at Wycombe Abbey, the streets were brilliantly illuminated with the electric light.

Change of Address.—Messrs. Marshall, Sons, and Co., the well-known engineers, have now completed their London premises at Marshall's Buildings, 79, Farringdon-road, E.C., where they have a large assortment of their productions for sale or letting out on hire.

West India and Panama Telegraph Company.—The estimated traffic receipts of this company for the half month ended the 31st ult. are £2,468, as compared with £2,290 in the corresponding period of 1883. The July receipts, estimated at £5,865, realised £5,932.

Private House Lighting.—The Hammond Electric Light Company have received instructions from Mr. W. C. Alexander to light with electricity his residence, Aubrey House, Campden-hill. The plant to be installed will be sufficient to run 90 incandescent lamps.

Electric Light at Harrogate.—The lamps used at Harrogate are the Weston arc lamps; besides the arc lamps, however, a number of the Maxim-Weston Company's new incandescent lamps are used, the current being supplied by a 240-light self-regulating Weston dynamo.

Business Notice.—We are informed that Messrs. Mayfield and Co. have taken over that part of Messrs. Paterson and Cooper's business relating to educational, philosophical, and experimental apparatus, Messrs. Paterson and Cooper confining their work more especially to electric lighting, telegraphy, and telephony.

Cuba Submarine Telegraph Company.—The number of messages passing over the lines of this company during the month of October was 2,588, estimated to produce £2,200, against 2,814 messages, producing £2,744, in the corresponding month of last year. The traffic receipts for the month of July, estimated at £3,200, realised £3,219.

Chrysanthemums and Electric Light.—With reference to our note on this subject last week, Mr. Frederick C. Phillips, of 2, Victoria Mansions, S.W., writes to us as follows:—"You may be interested to know that I am this week lighting the chrysanthemum show of Messrs. Cutbush and Son, at Highgate, by means of four of my new 10-ampere arc lamps."

Brewers' Exhibition.—With regard to our notice of this Exhibition, Messrs. Oppermann Brothers write:—"Seeing your notice in last week's *Electrician* on the electric light at the Brewers' Exhibition, we beg to draw your attention to the fact that the twenty-one lamps you mention as being used to light the British Gas Engine Company's stand were our new specialty lamps at 2s. 6d. each."

Oriental Telephone Company.—In a circular addressed to the shareholders of this company, the directors caution them against some misstatements which are in circulation, and against "blindly sacrificing their property," adding that the revenues of the company and of its affiliated companies have materially improved since the last report, while the expenses have been considerably diminished.

Society of Telegraph Engineers.—The next meeting is for Thursday, Nov. 13th, when the following papers will be read:—(1) "On the Theory of Alternating Currents, particularly in reference to two Alternate Current Machines connected to the same circuit," by J. Hopkinson, F.R.S.; (2) "An Account of Experiments with Alternate Current Machines," by Prof. W. Grylls Adams, F.R.S., president.

Electric Repeating Clock.—Sig. Bianchini has applied an electric contrivance to all the bells of a clock striking the hours and quarters, in such a way that, by simply making contact, the bells, which otherwise remain silent—say, during the night—indicate the time at the next quarter. A special arrangement also permits of making all the bells sound at pleasure, or only one independently of the others.

Gaulard and Gibbs' Generators.—As these secondary generators had no competitors at the Turin Exhibition, and the jurors had only to regard the scientific aspect of the question, without being troubled by considerations as to the cost of the current transmitted, they awarded to these exhibitors the 10,000f. (£400) prize offered for the best process exhibited for the distribution of electrical energy at a distance.

Awards at the Healtheries.—The list of awards is prefaced with the remark that it has been decided to defer the adjudication of awards to exhibitors of electric lighting apparatus in Class 26 until the exhibits included under this head in the Inventions Exhibition of next year are dealt with, in order that the necessary comparative tests (which must extend over a long period) may be thoroughly carried out. Anent this matter see our leader of 20th September last.

International Society of Electricians.—The ordinary monthly meetings of this society were resumed on the 5th inst. in the hall of the Société de Géographie, Paris. The papers

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on the list were on the following subjects:—Definitions, Conventions, Notations, and Electric Symbols, by E. Hospitalier; Mechanical Corrector of the Deviations of Mariners' Compasses, by Captain Fournier; and Electric Signals in the French Navy, by A. de Meritens, with experiments.

Electricity for Nothing.—At the Manchester Police-court last week, an elderly man, named Harrison, was committed for trial on the charge of obtaining money under false pretences. He had received £180 from a Mr. Frith in order to bring his invention before the public, the said invention being a self-acting apparatus, which could be put in a box like a gas meter, and was to supply electric light by simply turning on a tap, and work tramcars or locomotives without coal or motive power.

Extension of the Electric Light.—We understand that the Stanners Close Steel Company has decided to extend its electric light plant by the addition of some ten Brush arc lamps, six of which are now being erected. As this firm has been employing the light for some time, the present extension speaks well for its success. The work is being carried out by the Hammond Electric Light Company, which also carried out the work at the Grand Hotel, Eastbourne, mentioned in our last issue.

Great Northern Telegraph Company.—This company notifies that the rate to Canton has been reduced to 8s. 9d. per word from the 1st instant; and that a telegraph station has been opened at Swatow, for which place messages can now be accepted for transmission by this company's lines at the rate of 10s. per word.—The traffic receipts of this company for October amounted to £26,000; from 1st January to 31st October, £234,680; against, in the corresponding months of 1883, £215,285, and of 1882, £203,575.

A New "ism."—Professor Lambroso, writing to the *Revue Scientifique*, has given a new name to an old state of things—say condition of the mind. He calls "*misonéisme*" (from μίσος, hatred, and νέος, new), that dislike to change, even for the better, which is distinctive of most animals, man in particular, and perhaps Englishmen in the highest degree. *L'Electricien* asks if an instance of "misoneism" is not afforded by the English sticking pertinaciously to their old system of weights and measures, which leads to everlasting complication.

Electric Light in the Distillery.—The Anglo-American Brush Electric Light Corporation has placed incandescent lamps throughout the premises of Messrs. Andrew Usher and Co., distillers, Sciennes, Edinburgh. Besides effecting a saving of 33 per cent. in the cost of illumination, the new light will render the outbreak of fire a matter of very remote contingency, even in what is known as the spirit safe at the worm end, where the greatest care had to be exercised in the use of gaslight, owing to the liability of the spirit fumes to ignite.

Eastern Telegraph Company.—This company notifies the opening of a new station on the island of Perim, at the mouth of the Red Sea. The rate to this place is the same as to Aden, viz., 3s. 9d. per word. The company also announces the opening of a new station in China (Swatow), the rate for telegrams to this place being 10s. per word. The charge for telegrams to Canton is reduced from 10s. to 8s. 9d. per word. —The traffic receipts of the company for the month of October amounted to £53,865, and to £47,624 in the corresponding period of 1883, showing an increase of £6,241.

Close of the Health Exhibition.—The doors of the Healtheries were finally closed on Thursday, 30th October, to the great regret of many, who would have at any rate liked the week lost before the opening to have been made up by an equal prolongation before the close. In less than six months, during which the Exhibition remained open, it was attended by 4,167,683 persons, or 1,464,632 more than the admissions to the Fisheries of last year. It is certain that the clear profit will be at least £30,000, and more likely £40,000, of this, the most successful exhibition that has ever been held.

The Catastrophe at Glasgow.—Without dwelling on the details of this terribly cruel fatality—cruel alike on account of its prime cause and the want of means for prevention—we will put on record here the suggestion made by M. Buls, the Burgomaster of Brussels, for preventing a similar calamity. He would provide ample and independent exit doors opening outwards, kept shut by the attraction of bolts forming the armatures of powerful electro-magnets. On any alarm being raised, he would, by a single switch, break contact in all the wires and allow the doors to be forced open by strong springs.

Electric Burglar and Fire Alarm.—An improved electric burglar and fire alarm, one of which, we are informed, is being fitted up at Scotland-yard, was shown in action at the recent Brewers' Exhibition by Mr. G. L. Pearson, of Holloway, N. When the current from a battery or accumulator is switched on at night, any tampering with the doors or windows interrupts the circuit, causes a bell to ring, gives an alarm at the nearest police station, and, by means of an arrangement like the new electric gas-lighters, lights a red lamp with three bull's-eyes shining in three different directions.

Brake Worked by Electricity.—The Walker brake, worked by current from a dynamo on the locomotive, has been tried on the Alta Italia Railway. In each waggon, one of the axles is surrounded by a loose metal sleeve. When the current passes, it causes some pieces of soft iron to enter recesses, thus engaging the sleeve with the axle so as to revolve with it. A steel chain, attached to the sleeve, acts on a system of levers which tighten the brake blocks on the wheels. On the line between Turin and Orbassano, a train running at about 15½ miles an hour was pulled up in six seconds and in a distance of 60ft.

Prospecting for Minerals by Electricity.—Our old friend Dousterswivel's divining rod must certainly give way before the electric arrangement which hails from the other side of the Atlantic. Two iron bars, connected at their upper extremities by a lead including electric bell, are driven into the earth where ore is supposed to exist. If the bars do not encounter a vein, the circuit is closed by the earth, and the bell coil is arranged so that the bell shall not ring. If, on the other hand, a metallic deposit occur between the bars the circuit becomes very feeble, and the bell gives forth no uncertain sound.

Electro-Musical Effects.—The Alhambra—not in Spain but in Leicester-square—has reverted to the only entertainment for which such a building is suitable—viz., a variety entertainment like that of the Paris Folies-Bergère and the Brussels Eden-Theatre. The Bozza troupe are repeating a buffo-musical performance that they have already given in several Continental cities. Sig. Carlo Bozza plays the "Ranz des Vaches" on a piano-harmonium, working from the keyboard, by the electric current, all sorts of *obbligato* effects, such as the beating of drums and the blowing of horns, disposed at various points about the auditorium.

The Insulite Company.—A special meeting of this company is called for the 17th inst. for the purpose of confirming

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the following resolutions which were passed at a previous meeting:—"1. That this company hereby adopts the agreement dated October 22, 1884, made between this company of the one part and the British Insulite Company of the other part, being the agreement mentioned in the notice of this meeting (dated October 10) as providing for the transfer to the British Insulite Company for the assumption by the last-named company of this company's assets and liabilities. 2. That it is hereby required that this company be wound up voluntarily."

Gas and Electric Light.—Speaking at Huntingdon the other day, Lord R. Churchill is reported to have said:—"Well, now, let us take another subject, not perhaps of such great importance, but still of importance to our urban population. I mean the question of electric lighting. That is a matter which promises to be a source of the greatest possible comfort and economy to our urban population. But Mr. Chamberlain took it in hand, with the result that electric lighting has for a time been utterly knocked on the head, and all enterprise and all invention for the time has been crushed, while those monsters of exorbitant extortion, those most mischievous monopolies—the gas companies—have been given a new lease of life."

Electric Light at Eastbourne.—On the report of the Lighting Committee being brought before the Town Council the other day—which report was against continuing the electric light for financial considerations, notwithstanding a petition in its favour—Alderman Pearson said it was with feelings of regret that the committee could not comply with the request of the memorialists and continue the electric light in the streets, and Councillor Chambers thought the light should not be cut off without a chance of having it again; but Alderman Pearson explained that the columns were the property of the Electric Light Company, and accident might arise from their being allowed to remain. Ultimately the report was adopted, and Eastbourne will be left in semi-darkness during the winter months.

New Lightning Conductor.—The setting on fire by lightning of the church at Belleville (an industrial faubourg of Paris), which was fitted with three lightning conductors and a permanent controller, induced M. E. Grenet to notify to the Paris Academy of Science that for some years he had applied to several houses of the arrangement described in the old instructions of Gay-Lussac, and which permitted him to protect buildings absolutely. He uses a copper band, 3 centimetres (1½in.) wide and 2mm. thick, traversing all the ridges, and surmounted, if necessary, by small points, also of copper, placed on the salient angles, and reaching to the earth with a surface of a square metre, represented by 15 metres of the same band placed in a trench, or connected with the underground gas and water pipes.

Electric Light at Hell Gate.—With regard to the electric lights in the iron tower at Hell Gate, which were put in operation on 20th October, an eye-witness records his impressions as follows:—The night was somewhat hazy, and all the lights on shore, except those in the tower, showed dimly. The tower, a skeleton structure, was not visible, and the first impression received on catching sight of the light was that the moon had risen. The light was more diffused and less glaring than the electric lights at Madison and Union squares. Buildings on Flood Rock and on the Long Island side of the Gate could be seen distinctly, but all their angles cast shadows of the most intense blackness. The water, whirling and surging through the Gate as the flood-tide swept up, could be seen as on a bright moonlight night with all the eddies visible.

Electric Lighting Memoranda.—Under this head the *Journal of Gas Lighting* says that the action of the Dynamicable Society for upsetting the Electric Lighting Act will probably be justified by the contention that the demand is not so much for special legislative facilities as for the removal of legislative disabilities. This plausible argument, however, will only be accepted as valid when it can be shown that the Electric Lighting Act is really to blame for the condition of affairs complained of; in other words, that electric lighting progresses better in countries where our terrible Board of Trade has no existence. Until this is proved the Act will remain unrepealed; for it will keep the way open for that perfect system of electric lighting which has not yet been produced, notwithstanding the pretensions of the syndicate of 1882. The note concludes with the statement that, whatever be the cause, it is certainly a very dead time at present with all electricians, except those who are making the most of their opportunities in the way of lighting steamships.

Boycotting the Monday Pops.—An over-heated frequenter of St. James's Hall, who signs himself "A Regular Subscriber to the Monday Popular and Richter Concerts," writes to us pointing out the fact that St. James's Hall being less stifling than usual at the first Monday Popular Concert was probably only due to the 'cold, biting wind.' The following night it appears there was no ill wind to blow the concert-goers any good. The hall was as hot as ever, which our correspondent attributes to the fact that 'the hall is over the dining rooms, and these are over the kitchens, both of which places are lighted with gas.'" The suggested remedy is to substitute electric light throughout the building. To bring this about the following suggestion is made: "Let a number of the regular subscribers to the concerts given at St. James's Hall agree not to renew their subscriptions unless the whole building is lighted by electricity, and let them inform the directors of the hall of this agreement." Which indeed would not be a bad plan. But when did concert subscribers ever combine in an organised strike?—*Pall Mall Gazette.*

The Creil Experiments.—We learn from the *Bulletin* of the Cie Internationale des Téléphones that, though the syndicate founded by Baron Rothschild has the sum of 500,000fr. (£20,000) at its disposal, for conducting the trials in connection with M. Marcel Deprez' system of transmitting electric current, the committee, which holds its sittings at the Paris Northern Terminus, considers the expense will not exceed 400,000fr. (£16,000). The programme of the experiments has been drawn up so as to carry out, for several weeks together, the working of a central station for the generation of current and its transmission to a distance under the conditions that would be met with in actual practice, while analysing all the details, following all the transformations of energy and determining the influence of each of the intermediate elements with respect to leakage and consequently useful result. It is to be set at rest how far this system is advantageous, if it permits of distributing the current transmitted, what reliance may be placed on electric generators; and lastly all the particulars essential for appreciating the industrial value of the invention are to be brought together.

Telegraphic Communication Without Wires.—Under this title *L'Electricien* recalls Professor Graham Bell's experiments on the Potomac river, for effecting communication between two vessels a mile and a quarter apart, one carrying a dynamo and the other a telephone, each with the two leads dipping into the water, but with no conductor except the water

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between the two vessels, the sole condition being that the two circuits have not the same potentials. Our contemporary then mentions Professor Trowbridge's proposal for the intercommunication of ships at sea, and the fact recorded by Mr. Preece that this system was put in practice for telephoning between Southampton and the Isle of Wight while the regular working of the cable was interrupted, and then goes on to say that the American Association ignored the experiments in this direction made in 1870 and resumed in 1876 by M. Bourbouze, between the Pont d'Iena and the Pont d'Austerlitz, at Paris. If the experiments in question were not followed up by practical results, they do not the less deserve to be put on record; and they would probably have made more noise if the Bell telephone, only just invented, had been known in France.

INCANDESCENT LAMPS V. PETROLEUM.—The owners of the steamer "Maasdam," of Rotterdam, which was burnt at sea on the 24th ult., will probably have their attention very forcibly directed by this costly accident to the advantages of the incandescent system for ship lighting. The danger of using petroleum for ships' lamps has been pointed out more than once, and now we have an apt illustration of it in the destruction of a large vessel in so short a space of time that, to quote the report of the accident in the daily papers, "neither passengers nor crew were able to save any of their effects." Surely the money lost by the burning of the "Maasdam," whether the loss fall on the owners or the insurance companies, would have sufficed to fit many such vessels with electric lights. We know that "the fault of the Dutch is giving too little and asking too much," but surely their well known commercial acuteness will show them that a foolish pennyworth of petroleum is likely to cost them more in the end than a pound wisely spent on incandescent lamps. Even supposing that steamers must carry petroleum, and that a tank of this oil were to leak owing to heavy weather, as in the case of the "Maasdam," there would be no danger whatever in searching for such a leak with a portable incandescent lamp. But to hunt for a leak in a petroleum tank with a flaming oil lamp is as foolish and dangerous as to search for an escape of gas with a light, and in the case before us the result was equally sudden and disastrous.

AN EVIL AND ITS REMEDY.—A correspondent to the *Journal of Gas Lighting* complains of the serious failure of the electric light at the Promenade Concerts one night when he happened to be present. He says that, just as the orchestra was performing a grand selection, and at least 1,500 persons were present, the whole of the electric lights went out, leaving the building in semi-darkness. But lo! in one or two minutes the benignant gas, which had fortunately been kept alight in reserve was turned on; and additional burners were lit as soon as possible. "What would have been the consequences had the gas not been ready lit for this emergency? It is hard to say," he moralises. We say that this backing up of the electric light by gas is a great mistake, besides entailing additional and unnecessary expense. Let every pot stand on its own bottom. What would have been the consequence if the supply of gas had suddenly run short at the gas holder, or the main been cut in two by an explosion, or any other accident? Why the audience would have been where Moses was, just as much as they were when the belt slipped off the dynamo, or whatever might have been the cause of the sudden extinction. The proper course to be pursued is to run the lamps in two or three separate circuits, so that an accident is hardly likely to occur to all at once. Keeping the gas on in reserve is like providing engine tenters with automatic alarms, which only make them neglect their duty. Employ a good steady staff, take every precaution against accident, and trust the rest to Providence.

THE POST OFFICE AND THE TELEPHONE COMPANIES.—The following, of which we could only give a brief note last week, is the full report of what took place in the House of Commons on Thursday, the 30th ult.:—Mr. Kenny asked the Postmaster-General whether it was a fact that a proposition had been made to Government to buy up the telephone interest of the United Telephone Company and its affiliated companies for the sum of £2,000,000. Was it true that, as stated in *The Electrician* of the 25th of October, 1884 (p. 525), the Postmaster-General had recently given a large order for Gower-Bell telephones to the United Telephone Company, and was it true that the price to be paid by Government for these instruments was more than ten times the actual cost; was it true that a law officer of the Crown had given an opinion (advertised in *The Times* and other morning papers of the 28th of October) that there was a telephone which did not infringe the patents of the United Telephone Company; and, if so, whether, in the face of this opinion, the Postmaster-General approved of paying such exorbitant prices to the United Telephone Company for the instruments he required for the public service.—Mr. Fawcett said: In reply to the hon. member I beg to say that no such proposition as that suggested for the purchase of the telephone interest of the United Telephone Company and its affiliated companies has been made to me. An order for 250 Gower-Bell telephones was given to the United Telephone Company on the 25th of May last; but the price to be paid is not ten times, nor anything like ten times, the actual cost. I should have been very glad if I could have got them cheaper than the price paid. The opinion of the Solicitor-General, published in the papers, was not given in his official capacity as law adviser to the Government, and until I read it yesterday in the advertisements referred to I was not aware of it. This being so, I am unable at present to say what course it will be desirable to adopt with regard to the future purchase of telephones for the use of the department.

SOLAR INDUCTION.—In a note to the *Académie* on the elementary force of solar induction, the periodical duration of which is a mean day, M. Quet thinks it best to wait for more complete investigations before coming to any conclusion, and that it is advisable to isolate as much as possible the elementary forces from each other, so as the more easily to examine their characteristics. In following this course for the principal forces, he deals with that one which corresponds with a mean solar day, and puts forward the following general proposition:—"The force of induction produced by any system whatever of electric currents on a particle, m, of positive electric fluid is perpendicular to the speed $o\,v$ of this particle, and to the direction $o\,d$ of the line of force which passes through the point o of the magnetic field; it is directed towards the left of the personified speed and regarding $o\,d$; lastly, it is measured by the area of the paralellogram constructed on $o\,v$ and $o\,d$. If f be this force, and e the angle $v\,o\,d$, the following equation will be obtained: $f = m\,d\,v \sin. e$." In the case of the sun acting on the earth, the action on the mass m at the centre of the globe will be directed from the centre of the earth towards the centre of the sun, or in the contrary direction, according as positive or negative electricity be in question, or according as the Austral magnetic pole of the sun be to the north or south of the ecliptic. For all the other points of the earth, the similar forces will be sensibly equal and parallel to the preceding. The electric currents of the globe are

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therefore continually subjected to two systems of forces, which converge, some to the centre of the sun and the others to the opposite point. As the celestial sphere revolves, taking with it the sun, which has its own motion in addition, the forces of induction will follow the sun or the opposite point, will revolve with the celestial sphere and will complete their revolution in a mean solar day. These forces will preserve their intensity; and their direction will be subject to a variation of periodical duration equal to a mean solar day. This result, which is obtained by very simple means, may serve to verify those of the general analytical theory put forward.

Ship Lighting.—The following gives fuller details of the lighting of the ss. "Olympo" than our short note of October 25:—This steamer, built by Messrs. A. and J. Inglis, Pointhouse, Glasgow, for the Meusagerias Flureales a Vapor, is sister ship to the "Saturno," recently built by the same firm. The installation consists of 320 incandescent lamps of 20 candle-power, which are divided into six circuits, each of which is controlled by a switch in the engine room. Each state room is provided with a lamp having a separate switch under the control of the passenger. An adjustable resistance is placed in the field magnet circuit, and the speed of the engine is controlled by an Auldo reducing valve placed close to the switch board. The dynamo used is one of the Elphinstone-Vincent type, capable of lighting 400 lamps, and runs at 900 revolutions per minute, with an electromotive force of 90 volts. Over each gangway is placed a large lantern, each lantern containing a group of six incandescent lamps of 20 candle-power. The lights are suspended over the gangways by strong brass swinging brackets which can be shipped or unshipped at pleasure. By these means a splendid light is thrown over the gangways when passengers are being landed or shipped, or when landing or discharging cargo. A novel feature in ship-lighting is the introduction of storage batteries. There are 45 cells which can be charged while the dynamo is running and lighting lamps, and this accumulated energy may be used for lighting any portion of the vessel when she is in port and steam cannot be obtained. The engine used for driving the dynamo is one of J. and H. Gwynne's "Invincible" type. All the work connected with the installation has been carried out by Messrs. Wm. Harvie and Co., Broomielaw, Glasgow, under the supervision of Mr. Montague Scott, their chief electrician. The pendants, brackets, &c., which are of an elaborate description, were likewise designed and manufactured by Messrs. Harvie, who have carried out the work in a highly satisfactory manner. The steamer presented a beautiful spectacle when lighted up, and the steadiness of the light was much admired by the company on board.

Signals for Telephonic Communication.—A very complete system of telephony and signalling is carried out in the shipbuilding yard of Messrs. Denny Brothers, at Dumbarton. As they practically execute the whole of the work connected with the building of ships in their own yard, even to the most artistic parts of the decoration of the saloons, it will readily be understood that a good telephonic system is of great importance. The means adopted for intercommunication are quite unique. The telephonic exchange in use at Dumbarton resembles the central telephone exchanges in London and elsewhere. Every department can hold instant communication with any other department; but there is this important advantage. By means of carefully planned signals, it is possible to call to a given spot the head of any department, no matter where he may be at the time. A mast 90ft. high is erected in the centre of the yard; and, when any member of the firm desires the attendance of another partner, of the manager or any other official, he goes into the nearest telephone station, about thirty of which are distributed over the yard, and puts himself in communication with the switch room at the exchange. Having been connected with the attendant stationed in a telephone cabin at the mast, a signal representing the official who is wanted is hoisted. As soon as this signal is run up, the official called for either sees it or is informed by somebody else that his number is on the mast. All he has to do is to go to the nearest telephone station and connect himself with the person who has called him. Before long, further telephonic communication will be established with the National Telephone Company, Glasgow, so that a conversation may be carried on with any of the thousand subscribers to that exchange; and, by the trunk system of the company, it will also be possible to communicate with the exchanges at Edinburgh, Paisley, and Greenock. To such a pitch of perfection has the telephonic system been brought in Scotland already. Indeed, the longest talking line in Great Britain is that between Edinburgh and Glasgow, a distance of fifty miles; but conversations have repeatedly been held between Greenock and Edinburgh, *viâ* Glasgow, which is a distance of seventy-eight miles.—*Pall Mall Gazette.*

Electric Boiler Alarm.—Herr R. Schwartzkopff has devised an electric indicator which, fitted to a steam boiler, gives warning of insufficiency of water, excess of steam pressure, heating of the plates, and superheating of the water under normal pressure. The apparatus consists of two concentric pipes, the inner of brass, open at top and closed at bottom, and reaching below the lowest water level, and the outer of iron, closed at top and open at bottom, the lower end corresponding with the lowest water level. The annular space between the two is placed in communication with a chamber at the top of the apparatus by a small spiral tube. When the water is at its normal level, and before being heated, it stands at the same height in the boiler and in the annular space; but as soon as the pressure increases, the water rises in the annular space until it reaches the chamber, freed from air by a small orifice, closed by a stop-cock. This column of water is maintained as long as there is sufficient pressure and the water level is above the normal, when the column becomes cooled by radiation, and the temperature of the chamber descends below boiling point. As soon as the water level falls below the normal, so as to uncover the orifice of the outer pipes, the column falls, and the steam rises into the annular space to the chamber, causing the temperature to rise above boiling point, and thus indicating a deficiency of water by means of an electric signal. In the inner pipe there are two copper wires, insulated from one another and connected with the poles of a battery. They are enclosed at top and bottom of the apparatus in brass boxes, the bottoms and covers of which are of an insulating substance. The upper box contains a ring of metal fusible at boiling point; and, as soon as there is a deficiency of water, the ring melts, and the first drops of metal are collected in a funnel-shaped receptacle, thus making contact between the wires, and causing bells to ring or signals to manifest themselves. The lower box, which is immersed in the water of the boiler, has the same temperature as that of the steam; and the ring is formed of an alloy so mixed as to melt at a temperature corresponding to whatever pressure may be fixed upon as the limit. In case the plates should heat, a signal is also given by the lower box, the ring of which melts through the heat radiated from the plates. A Leclanché battery is used to give the current; and it is said that the fusible rings may be replaced, after action, in ten minutes.

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CORRESPONDENCE.

MINIATURE INSTALLATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Having seen in your paper of October 25th, under the heading of "Notes," a paragraph entitled "A Miniature Installation," could you, Sir, or one of your contributors inform me through your columns as to the *approximate* price of similar installations of sixteen lamps or twenty-four lamps. Such a method of lighting would be invaluable in small country houses, or even in town houses, where gas is bad or unobtainable.—Yours, &c., GEO. H. MARRIOTT.

12, Alexandra-place, St. Andrews,
Fife, N.B., Oct. 29, 1884.

THE HEALTHERIES FOUNTAINS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: A question has arisen as to whether the coloured lights thrown upon the fountain at the Health Exhibition proceeded from the island or from an elevation in the neighbourhood of the clock. If you will kindly answer it through your correspondence column I shall be obliged.

To make my meaning clearer I would say, Where did the operator stand?—Yours, &c., J. G. A.

Hull, 1st November, 1884.

[A full description of these fountains was given in our issue of September 27, where the desired information will be found.—ED. *E.*]

THE PHILADELPHIA EXHIBITION.—VI.

(FROM OUR SPECIAL CORRESPONDENT.)

PHILADELPHIA, OCT. 16.

The Electrical Exhibition was closed last Saturday at 11:30 p.m., as announced; but there were no ceremonies save a burlesque performance by some of the exhibitors. The hour of closing had been extended from 10 until 11:30 p.m., and about 11 o'clock some of the facetious electricians appeared with silk badges bearing the initials "M.E.O.K.," which being translated became the "Mystic Electrical Order of Kazoos." The kazoo is a diabolical musical instrument sold to small boys at the Exhibition. It makes a horrible noise, and has the disadvantage that anybody can play it without a lesson. Armed with kazoos and preceded by a big bass drum, the mystical order paraded about the hall, and then held a burlesque meeting. Some of the facetious spirits that organised this demonstration had previously distinguished themselves by a witty publication. For the information of the public Professor E. J. Houston had prepared and printed short primers of electricity, which undertook to explain "Batteries," "Dynamo-Machines," "Electric Lighting," and similar subjects, in plain language, and within the compass of little four-page pamphlets. They served their purpose well enough, but were necessarily rather ridiculous to those who understood the subjects thoroughly. They were consequently fair game for satirists, and somebody saw and accepted the opportunity. Primer No. 0 soon made its appearance. It undertook to describe "Dynamite Electric Machines," and some of its passages contained clever hits at the other primers and the inventors and exhibitors. Here are a few passages:—"Dynamite electric machines may be painted a great variety of colours without increasing their efficiency. This affords scope for aspiring inventors." An illustration shows a boy turning a grindstone:—"When the crank is put in rapid rotation by a small boy under the normal conditions of this building, he immediately becomes incandescent —*i.e.*, red hot. This effectively illustrates the transformation of energy."

"There are two kinds of electric lights, namely:—

"*Our* kind and the other fellow's kind.

"Our light is much lighter than the other fellow's light.

"The other fellow's light is surrounded by a cloud of non-luminous verbosity."

This burlesque primer had a very large sale, chiefly among the electricians and exhibitors. I mention it and the tomfoolery of the closing night only because it is characteristic, I believe, of American irreverence. There was plenty of science and hard work, but there had to be a little fun, too, to brighten the scene and lighten the labours of the exhibitors. No accident occurred during the Exhibition, but the managers were extremely fortunate in having forty days of good weather. There were only two or three slight showers of rain in all that time. A soaking rain, penetrating to the building, might have resulted in a very different story.

In round numbers the expenses of the Exhibition amounted to $100,000. This included about $40,000 spent in the erection of a building, which is to be kept standing for four years for other specialty exhibitions. There were about 300,000 visitors, and the cash profits amount to at least $10,000. The Franklin Institute has also obtained a valuable library on electricity, and a large museum of electrical machines, models, &c. The test instruments used by the examiners have been purchased for the Electrical Section of the Franklin Institute, to be used by committees of that body in testing new inventions submitted to them for examination.

On the last day of the Exhibition Griscom's electric railway was put in operation. It presents a few novel features, and so far as preliminary tests go the motor promises to be very efficient. Mr. W. W. Griscom, the inventor, exhibited at Paris, I believe, his double induction motor, a little machine weighing only 2½lb., and run by a battery intended for household use in operating sewing machines. The magnet is a continuous ring with polar extensions inside and wound between these extensions. The armature is of the Siemens or H form. In the electric railway motor the magnets are of the same ring form, but the armature is a modified Gramme ring. Three rails are used, the middle one solely as a conductor of the current used, and one of the other rails as a return conductor. The current is taken up by metal brushes sweeping the rails. It is now being tested. The examiners are still hard at work, and are likely to continue for several weeks. Exhaustive tests are being made not only of electric machinery proper, but of steam engines and boilers used to drive the dynamos. It is not likely that the examiners' reports will be ready before the 1st January.

One of the curious exhibits which I believe I have not mentioned was Dolbear's telephone receiver. Professor Dolbear was one of the early experimenters with the Reis transmitter. He has produced a very different instrument, which is, I believe, the clearest and loudest speaking telephone (except Edison's chalk telephone) yet exhibited. He uses a current of high electromotive force. A diaphragm is arranged to whose centre is fastened a small platinum wire which carries at its extremity a small piece of carbon in rubbing contact with a second piece attached to a fixed support. This arrangement is in the circuit of a galvanic battery which also forms the primary of an induction coil. The secondary coil is continued to the line. The receiver consists of two plates preferably of thin iron, to each of which one pole of the secondary coil is attached. [The circuit may of course be either metallic or with return through earth.] The plates of the receiver are parallel to each other and separated by an air interval of about one-sixteenth of an inch. The secondary or line current is therefore broken or interrupted by an air space, but being of high electromotive force is able to exert an influence on the two diaphragms, and the attractions and repulsions of the two oppositely excited discs are sufficient to reproduce articulate sound. The most curious thing about this telephone is that it may be used without a wire, for a short distance at least. Holding the receiver to one's ear and disconnecting the line wire (the ground being maintained) the line wire may be removed to a distance of at least four feet without any disturbance of the efficiency of the phone. This extraordinary result was frequently shown, but the limits of the experimental room, a mere box, prevented any extensive tests.

I have not space in this letter to describe Delaney's synchronous multiplex telegraph system, but think it worth while to note that it was successfully worked during the

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Exhibition over two hundred miles of wire, or from Philadelphia to New York and return. The test was a severe one, as the line used is partly aerial, partly underground, and crosses several rivers in cables. Six Morse circuits were worked at average speed over the single line without interference. The system is intended to work either Morse or printing instruments, or both, at commercial speed, a single line accommodating either six Morse instruments or twenty-four printers, or a proportionate number of both. The chief difficulty in the way of success is likely to be delay in getting rid of the static charge on long lines. The synchronism appears to have been mastered, but the description of this I will have to leave for another letter.

LITERATURE.

Die Elektrische Beleuchtung mit besonderer Berucksishtiguny der in den Vereinigten Staaten Nord-Amerikas zu Central-Aulagen vorwiegend verwendeten Systeme. By Dr. Ernst Hagen. [Berlin: Julius Springer.]

A host of books on electrical subjects, written to the publishers' orders, and containing only vague information, but much of would-be scientific small talk, have of late made their appearance in Germany. To speak of that kind of literature is not a pleasant task for the critic, and we have therefore abstained from noticing it in our columns. The above work, however, is a bright exception, and merits to be known. If not quite faultless from a scientific point of view, it at least contains plenty of solid facts and precise information.

The author has been deputed by the municipality of Berlin to inspect the different systems of electric lighting in use in the United States, and to publish an account of them. This mission he seems to have faithfully carried out, so far as that part of the work is concerned which deals with the description of existing systems and with the data as regards cost of installations given by the manufacturers themselves. But if we come to look at his attempts at generalisation we cannot help regretting that he made it on comparatively so narrow a basis. The reader of the book will probably come to the conclusion that Dr. Hagen is not a practical electric light engineer, but rather a scientific man describing a few systems which have happened to come under his personal notice. For all that, the book is very useful, because on these few systems, which are important ones, it contains plenty of facts.

A literal translation of the title of the book is "Electric Lighting, with special reference to the Central Station Systems principally used in the United States."

The introduction contains the usual allusion to the necessity of artificial light for our modern civilisation and the insufficiency and danger of gas for this purpose. An interesting observation not usually made by writers on that theme is that carbonic acid produced chemically is not nearly so injurious as that contained in human exhalations. Of the former 1 or 2 per cent. may be mixed with the air without danger; whilst of the latter an admixture of ·06 per cent. is already insupportable. According to Dr. Pettenkofer, this is due to a subtle poison, the anthropotoxin, which is always combined with the carbonic acid exhaled. If Dr. Hagen be right in his assertion, then the old belief that one gas flame vitiates as much air as five persons would become untenable. Of the two parts forming the introduction, the first deals with the general principles of electro-magnetic induction, lines of force, resistance, current, electromotive force, the dynamic principle, arrangement of lamps in series and parallel connection, and similar elementary matters, which have been explained over and over again in nearly every book on electric lighting, and might, without prejudice to the present work, have been left out, the more so as Dr. Hagen only deals in generalities, and does not increase our knowledge where most needed, viz., in giving precise data by which electromagnets and armatures and their relation could be brought within the realm of exact measurement and calculation. He gives, however, a few tables on the cost of steam power, the efficiency of dynamos, &c.

The second part is more original and more interesting. Those desiring information as regards priority in the invention of the incandescent lamp will find here a brief history of the invention from Tobard's proposal, in 1838, to heat a small piece of carbon in vacuo by an electric current, down to Swan's and Edison's patents of 1879. The author concludes the introduction by saying that although the proposition, often put forward, that Edison is the only true inventor of the incandescent lamp, is utterly untenable, yet he has the great merit of having given the first impulse to make incandescent lighting a practical success, and of having introduced the central station system.

In Chapter I. we find a detailed description of the Edison central station in New York. The building, the boilers, steam dynamos, the apparatus for regulating the potential, cables and street mains are fully described, and a plan of the district served is given. A table giving the pressure at different points of the mains is of interest; from this it appears that the equalisation of pressure is almost perfect, the variation being between 107 and 108·9 volts. The author also gives a description of the manufacture of the Edison lamps in the Newark factory, and mentions the astounding fact that not less than three tons of mercury and 300 pumps are in use for exhausting the lamps.

The part of the description dealing with the Edison meter is somewhat disappointing; it contains nothing new, and no mention is made of the difficulty of incorrect indications on account of counter E.M.F. in the zinc plates. Some time ago there was an impression in this country that the Edison station supplies current throughout the day for motive power, in fact that this branch of the business is more important than the lighting. This Dr. Hagen denies completely; up to September, 1883, there was not a single motor fed from the Edison mains. When speaking of installations in other towns the author, on page 101, says that with any other but Edison lamps they would be simply impossible, since the large currents required by them (as for instance Swan's or Bernstein's lamps) would necessitate too large an outlay in conductors. Here is an instance of the error into which a writer can fall who is but imperfectly acquainted with his subject. The book is dated 1885, and Dr. Hagen ought to to have known that ever since the beginning of 1884 the Swan Company have manufactured 20-candle lamps requiring but ·65 ampere—that is, less than Edison's lamps.

Chapter II. treats of the installations of the United States Electric Light Company, who use Weston machines and Maxim lamps, the manufacture of which is clearly explained. In the third chapter, methods and results of measurements on incandescent lamps are given and tabulated. From these tables the improvements made in the time between the Paris and Munich Exhibitions can be seen. Here again we observe that the book is behind the period.

The cost of installations and the working expenses as compared to gas will be found in Chapter IV. As regards the cost of the plant, Dr. Hagen's figures are based on Edison's original prices, and are decidedly too high. We find, for instance, that a 200-light machine, 200 16-candle lamps, with holders and a rheostat for regulating the shunt current round the field magnets, are put down at £480, whilst at the present time an equivalent plant of English make could be had for about £270.

Chapter V., containing a theory of incandescent lamps, might have been omitted. It contains very little of practical value, and the concluding statement, that the light of an incandescent lamp varies as the third power of the electrical energy, has certainly not been verified by the experiments of Messrs. Preece and Trotter.

Accumulators find a place in Chapter VI., and over sanguine inventors would do well in reading it. Although only Planté's, Faure's, and Brush's accumulators are described, there is a clear theory given, applicable more or less to all the later forms.

The book concludes with some very sensible remarks on the danger of electric light to life and property, or we should rather say, on the absence of danger, if only some very simple precautions are used.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, *Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 *p.m.*

CONTENTS.

With our present issue is published the INDEX to VOL. XIII.

Notes ... 565
Correspondence ... 570
Philadelphia Exhibition.—VI. 570
Literature ... 571
Sweetness and Light ... 572
Mr. Fawcett ... 573
Robert H. Sabine ... 573
Daniell's Cell. By J. T. Bottomley. Illustrated ... 573
The Theory of the Dynamo-Electric Machine ... 575
The Disruptive Discharges from the Holtz Machine ... 576
Extraction of Metals by Electricity ... 577
Bucharest ... 577
The Use of Electro-Magnets for Railway Signals. By I. A. Timmis. Illustrated ... 577
Brazilian Submarine Telegraph Company ... 580
Companies' Share List ... 580

SWEETNESS AND LIGHT.

We are not sure from what source the political slang of the day has borrowed the phrase *to stew in their own juice;* but its application to the afflicted frequenters of what are called "places of amusement" is as accurately descriptive of the fact as it is flagrantly offensive to good taste. Prince Bismarck we believe is credited with this, as with many another inelegant barbarism; but unless the illustrious Chancellor's character has been belied he is not the man to approve of the stewing process unless it can be turned to his own advantage. Managers and proprietors of places of public resort, on the contrary, inflict the operation on their customers through sheer wantonness, or indolence, and in that respect resemble not the German but the English politician, who employs this hideous image as implying that the victims rather like being stewed, and that in any case it is no affair of his. We are glad to notice that some strong protests on the part of the sufferers by this misconception are finding utterance in the newspapers, and that it is being made plain to the caterers of public recreation that neither stewing nor baking ought any longer to have a place on the evening's programme. Both these ordeals have to be endured, apparently, by the audiences of the St. James's Hall concerts. According to a correspondent of the *Pall Mall Gazette* there is a large kitchen and dining room under the floor of the hall, both lighted by gas; and the heat from below thus added to the gas heated vapour above renders the atmosphere almost intolerable, to say nothing of its being in the highest degree unwholesome. It may be hoped that this protest will not pass unheeded.

The prolonged trials of electric lighting for interiors of places of amusement have proved entirely successful in, we believe, every case, and the marked improvement in their comfort has been greatly appreciated by the audiences. What the covered portion of the Health Exhibition would have been even in the autumn months of its existence had it been lighted by gas we can well imagine, but would have certainly declined to experience. Its four millions of visitors and more, sometimes numbering as many as seventy thousand in one day, the bulk of whom remained well into the evening, will we may confidently assert, be vastly diminished were the Commissioners to fall back upon the less wholesome as well as less beautiful system of illumination for a future exhibition. And what is true of the Healtheries applies to every place of public resort where electric lighting has had a trial long enough to assert its superiority over gas in the minds of the people frequenting them.

It is, we say, a great mistake on the part of the responsible managers of such places to suppose that the pleasure-loving public count excessive fuming and fanning—to put it inoffensively—as among the joys of the evening. We cannot all take our coats off as they do in the East End galleries; nor could we endure to see and feel the roof sliding off as it does at some of the theatres on the Continent. It is often alleged that the cause of the discomfort in English places of amusement is defective ventilation. But in this respect we are no worse off than our foreign neighbours. They certainly do *not* do these things better in France. Indeed, a single evening spent in a Parisian theatre would almost persuade us into the managerial axiom that the people "like it"—that is, like having all the preliminary discomforts of a Turkish bath without any of its after pleasures or benefits. But the French have a remedy, or, at all events, a palliative, which is not permitted to an English audience—they go outside in a body between the acts, perambulate the broad footways of the street, or loiter about in the airy *foyer.* The same with the concert halls during the regulated intervals of the performance. Neither our climate nor our thoroughfares will admit of this heroic stampede into the open air; and we have, therefore, to endure the premonitory pangs of suffocation, relieved occasionally by blasts of cold—a special device of the management—the probable consequences of which are even more alarming than the heat. In olden times, the *foyer,* as the name implies, was the place where the audience gathered together between the acts to warm themselves—literally, on the *hearth;* now they retire there to get cool. Nothing could better illustrate the change of atmospheric condition in the modern theatre, brought about entirely by the employment of gas.

The impetus given to the cause of electric lighting by the South Kensington Exhibitions is unmistakable, and the advantage to promoters will be far greater than anything they could have obtained through the winning of exhibition medals. The Commissioners have, we think wisely, abstained from awarding medals to the exhibitors of electric lights. Relative merit in this branch of illumination can only be determined after careful tests and comparisons, and these will be best deferred till the Exhibition of Inventions next year, as was suggested in our columns not long ago. Meanwhile, the absolute merits of the new illuminant have been demonstrated to an extent which cannot fail to be profitable to electric lighting engineers. The complaints to which we have already referred show that nothing less wholesome or less brilliant than the electric light will satisfy the public; and we hope to see before long an equal interest shown for the health and comfort of the dumb creatures who, at Live Stock Shows, are penned up in a stifling atmosphere for

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nearly a week at a stretch, where the simple introduction of electric light would not only sensibly relieve their sufferings, but greatly add to the comfort of the visitors. A very gratifying proof of the progress being made was afforded in our advertisement columns last week, where the Metropolitan Asylums Board invited tenders from Electrical Engineers and Electric Light Companies for the lighting of the three hospital ships moored in the River Thames, near Dartford. If this installation—which is to be on a large and comprehensive scale—give satisfaction, similar invitations may be expected for town hospitals, where coolness is almost as important as light, and sweetness more than either.

MR. FAWCETT.

At the moment of our going to press the sad intelligence reaches us that Mr. Fawcett, the Postmaster-General, died suddenly at Cambridge on Thursday afternoon. For two or three days previously it was known to us that he was seriously ill, having had a fresh attack of pleurisy, a disorder which prostrated him for some months only two years ago. But Thursday morning's papers gave no inkling that his condition was precarious, and the organ which is generally credited with being in the confidence of the Government simply stated that the Postmaster-General was suffering from a severe cold. This renewed attack, however, notwithstanding the vigorous constitution it had to contend with, has proved fatal, and the country has lost one of its ablest men of letters and most conscientious of politicians. Mr. Fawcett's administration of the Post Office and Postal Telegraphs has been open to criticism; but we have never denied the vigour of his arm or the justice of his heart. He was a professional political economist, and as such his public actions were often guided by what seemed to be cold calculation rather than benevolence or humanity. This, however, was not his character in private life; and the sturdy independence of his political career was only equalled by the rare courage which enabled him to face the calamity that deprived him of his sight at a period of life when most men would have been overwhelmed by it. When stricken with blindness he determined to go on "as if nothing had happened." A public career which has been eminently successful, and, but for this untoward catastrophe, would have been illustrious, proves how resolutely he kept his word. Mr. Fawcett was engaged in important negotiations with the Telephone Companies, and his loss at this juncture will be seriously felt. It is probable that Mr. Shaw-Lefevre may succeed him in the office of Postmaster-General. Mr. Fawcett was in his 52nd year.

ROBERT H. SABINE.

Another electrician has joined the majority, in Mr. Robert H. Sabine, who was joint author with Mr. Latimer Clark of "History and Progress of the Electric Telegraph" and "Electrical Tables and Formulæ." Born at Dorchester in 1837, and educated at Bristol, Mr. Sabine was destined for his father's profession, that of solicitor; but this proving distasteful to him, he was sent to Manchester to study engineering. Here he became acquainted with the late Sir William (then Mr.) Siemens, who, in 1858, engaged him as assistant electrician. In the following year, he carried out a series of experiments with a deep-sea thermometer, invented by Siemens, on board H.M.S. "Firebrand," in the Mediterranean, and was afterwards handed over to Siemens and Halske, Berlin. He carried out the tests of the Malta and Alexandria cable, and also assisted Mr. C. W. Siemens in laying the cable between Oran and Carthagena. In 1867 Mr. Sabine engaged in business for himself as electrical and consulting engineer, being associated with Mr. Latimer Clark in work for the Pneumatic Despatch Company. He subsequently took the management of the late Sir Charles Wheatstone's works, afterwards the British Telegraph Manufactory. For some years he joined Sir Samuel Canning in partnership; but resumed his separate practice about a year before his death. Mr. Sabine, who was married to a daughter of Sir Charles Wheatstone, and leaves one son, was struck down about six months ago, and, although hopes were entertained of at any rate partial recovery, he breathed his last on the 25th of October, being therefore only 47 years of age.

DANIELL'S CELL.*

BY J. T. BOTTOMLEY.

I beg leave to describe a new arrangement of gravity Daniell cell which I have found manageable and convenient

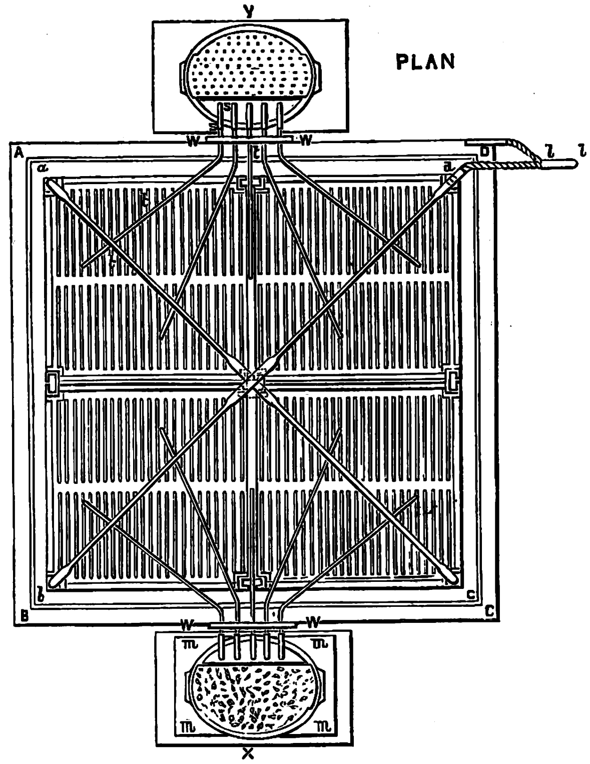
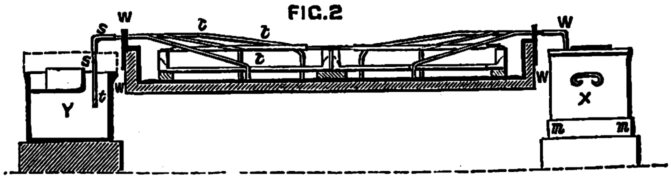


FIG. 1.

FIG.2



SECTION

for supplying continuously and steadily a very powerful current of electricity. It has proved of great service for graduating ampere-metres and for such purposes.

Fig. 1 shows the cell in plan, and Fig. 2 the same in section. The outer containing vessel is a large shallow tray of wood, very strong, but quite roughly made, and lined with sheet lead. The tray is 3¾in. deep, and with this small depth the lead can be beaten in, and autogenous soldering is unnecessary. The lead tray is very carefully varnished with spirit varnish, several coats being applied; and on the bottom of it is laid a

* A paper read at the Royal Society, entitled, "On a Gravity Daniell Cell of very small Internal Resistance."

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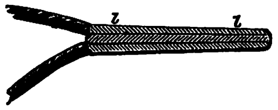
thin sheet of copper (0·2 millim. thick), or rather several sheets thoroughly connected together, as I have not been able to obtain a single sheet of copper large enough for my purpose. The copper sheet, varnished on the lower side, is attached in many places to the lead lining of the trough by soldered slips of copper, the solderings being thoroughly coated with varnish or marine glue. This copper sheet forms the copper plate of the Daniell cell.

The zinc of the cell consists of four of an unusually large size (56 centims., 22in. square) of the gridiron zincs used in Sir William Thomson's well-known tray Daniell, which is largely employed at most of the submarine telegraph stations in connection with the siphon recorder, and is a modification of the constant Daniell battery described *Proc.*, Roy. Soc., 1871, p. 253. These gridiron zincs rest on small blocks of wood at the four corners of each, and they are connected together by strong copper slips at the corners, and by means of two diagonals of thick copper rod which are soldered at the outlying corners and at the four meeting corners in the middle of the square.

Very powerful pairs of electrodes are soldered on at each of the four corners of the cell, though only one of these pairs is shown in the diagram at D. These electrodes are formed of flexible copper rope, terminated with two thick slips of copper which are fastened together mechanically, but electrically insulated, and form the flat duck's-bill shaped piece *ll*, shown in section, Fig. 3. The electrodes of any instrument which is to be connected with the cell may be also terminated with two copper slips, which are pushed on *over* the piece *ll* and held on by india-rubber bands.

The mode of supplying the cell with sulphate of copper still remains to be described, and it is this which constitutes its most important pecularity. The liquid contained ordinarily in the tray Daniell is a somewhat dilute solution of sulphate of zinc (sp. gr. 1·12 to 1·14), the lowest layer of which is saturated with sulphate of copper. The sulphate of zinc solution is kept at the proper density by occasionally drawing off quantities of strong liquor and replacing by pure water, testing by a hydrometer or with specific gravity beads. The sulphate of copper

FIG.3



is supplied by dropping a proper quantity of blue vitriol in crystals into the cell round the edges. This is sufficiently easy when the cells are of moderate dimensions, and where a large number of them are being constantly used and regularly attended to in a business-like way, as at a telegraph station. When, however, the size of the tray is very large, and when the cell is being used intermittently, this simple method becomes difficult and unsatisfactory; and, owing to want of uniformity of the solutions, the cell is rarely obtained in such a condition as to be ready to give the results which ought to be expected from it. The copper sulphate supplied in crystals does not dissolve sufficiently quickly and spread itself over the whole surface of the lower plate, and difficulties arise as to the dilution of the sulphate of zinc without stirring up from the bottom remnants of unused sulphate of copper.

To avoid these troubles, and to make the starting and stopping of the action of the cell easy and rapid, I have arranged to supply the sulphate of copper in the state of solution, and to deliver and to remove it very gently but very quickly, and also simultaneously, at many parts of the bottom of the cell.

X and Y are two earthenware tubs placed one on either side of the cell; and it should here be remarked that the cell is raised up from the floor on common building bricks. From these vessels a number of siphons or delivering tubes, *t*, *t*, *t*, of which ten* are shown in the diagram, proceed to different parts of the cell. The tubes are of thin glass, except the bend *ss*, which is of flexible india-rubber tubing, and enables the extremities to be taken with ease out of the vessels X and Y for clearance or for starting of the siphons. The tubes are held in position by passing through holes in the boards *w w*, and the glass portions are bent in a gas flame to the proper shape for delivering to the various parts of the bottom of the cell. The vessels X and Y are furnished each of them with a shelf of thin sheet copper perforated with many holes, the level of the shelf being considerably above the level of the extremities of the siphon tubes. On these shelves a large quantity of sulphate of copper in crystals is placed.

To raise the vessels X and Y up, and cause the siphons to run, two boards are provided which are pushed in beneath the vessels. One of these, *mm*, is shown beneath the vessel X in the figures. The boards are made of exactly the proper thickness to cause a layer of chosen depth to be run into the cell out of the vessels, or out of the cell into the vessels, according as the vessels are raised up on the boards or are lowered down when the boards are removed. The thickness of the boards depends, of course, on the relative sectional areas of the two vessels and of the cell. The depth of the layer which is spread over the bottom of the cell should be not more than one-eighth of an inch. The bottom of the cell must be very carefully levelled in order that the layer of charged liquor may be uniformly distributed, and that the half-spent liquor may be uniformly drawn off.

In setting up the cell in the first instance I commence with the cell charged with weak solution of sulphate of zinc (sp. gr. 1·12), while the vessels X and Y are charged with nearly saturated sulphate of zinc solution. This liquor is still able to take up a very large quantity of sulphate of copper; and water saturated with both sulphate of zinc and sulphate of copper is much more dense than saturated solution of either salt alone. When the cell is to be started the two reservoirs are raised into position. The thin layer of dense liquor spreads itself over the bottom in a few minutes, and the cell is ready for use. When the use of the cell is to cease the reservoirs are lowered down, and nearly the whole of the dense liquor runs back into them. This should always be done at night, or during any considerable time when the cell is to be out of use.

During the action of the cell sulphate of zinc is constantly being formed, and it is necessary frequently to run off a portion of the contents of the cell and fill up with pure water. I have planned for a system of tubes (arranged similarly to those just described) for siphoning off into independent vessels, and with a cell of very great dimensions such as I am now constructing they will probably be necessary. With the cell which I have been using for nine months, however, I have been able to dispense with them.

It only remains for me to give the dimensions of the cell now in use, and of a new one in process of construction. The tray of the former is 47in. square inside measurement, and 3¾in. deep. The zincs are each 22in. square, and are raised up ¾in. from the bottom. The copper sheet is about 0·2 of a millim., or 0·008in. thick. It is probable that it would be better a little thicker. With this cell I can command about 45 amperes for hours together at any time, only requiring to take now and then a fresh supply of sulphate of copper from the reservoirs. The new cell which is in process of construction is 69in. long by 46in., and 3¾in. deep. It has four reservoirs, and six zincs placed in two rows of three each.

P.S.—In the foregoing paper I have described the construction and capability of a cell, whose dimensions are given, constructed about the beginning of July, 1883. It was found necessary, almost whilst I was writing, to take the cell to pieces, as it had become blocked up with copper deposited in the natural course of nine months' working. In putting the cell together again, with attention to *small particulars*, which I shall not describe, as they will naturally occur to anyone who desires to use the arrangement, but which, I need scarcely remark, make, with such great currents, all the difference between success and non-success, I have obtained, through a current galvanometer of which the resistance is $\frac{1}{500}$ of an ohm, a current of 63 amperes which was quite steady.

* I have recently doubled the number with great advantage.

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THE THEORY OF THE DYNAMO-ELECTRIC MACHINE.*

DISCUSSION.

Professor ELIHU THOMSON: Mr. Chairman, I have been at work on dynamo machines for a long time, and my experience teaches me that some of the statements made are not correct. For example, there is a factor that has been omitted in regard to the extension of poles of magnets. We have a figure showing an extended pole piece, under which an armature is revolved. It is stated that the lines of force find it easy to go this way (arrows, Fig. 5). I do not think so. We find, on examining the machine during its motion that the armature

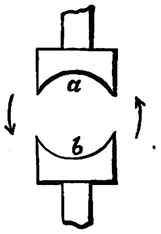

FIG. 5.

itself is a magnet of an opposing character, that it produces poles which are opposing the magnetism of the field poles, and if the armatures are of uniform size and section throughout, that the magnetism developed here in opposition to the field of magnetism will be same as here (indicating). Consequently, you have an opposing force to the field magnet at this point greater than it would be there (indicating), and, consequently, you have again produced a loss of magnetic force by going this distance.

Another fact—and this is what may happen very readily—there is a field running up the side of the magnet and turning in again. By the extension of the poles, carrying your magnet along here, you will obviate to some extent that difficulty.

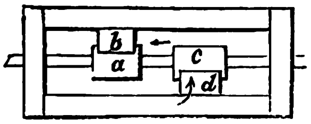

FIG. 4.

Then we had the statement made that one set of magnets is better than two opposing sets, as in certain well known forms of machines. I would like to take exception to that also, and for very simple reasons. Take away one magnet and you give every chance for this kind of action, and taking into consideration the fact that the armatures are crossing the magnetism of the field magnet when it is revolving, it becomes extremely simple to see. Place another magnet here (*a*, Fig. 4), and you force the magnetic lines through the armature, and

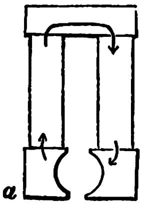

FIG. 3.

you consequently have a much better machine. That leaves out of consideration the fact that you have a small plate of material (of only two and one half or three inches thick in case of Fig. 3) in proportion to the magnet, which has enormous reaching power, if you may choose to call it so. We have an iron plate here (*a*, Fig. 3). Now, taking into consideration again the enormous currents that are developed in that armature opposing the magnetism, that it passes the magnetism of the field down through the armature, you see what a short-circuiting of the field of the armature is made when the iron plate is put in any sort of proximity to the ends of the field poles.

Again, take the form of the machine where we have the field magnet in two pole pieces, and we bring the iron down the side to close the magnetic circuit; we bring the piece out in that manner (Fig. 6). The question arises (I have not investigated the subject fully) whether the loss by magnetic short-circuit will be made up in part by the external magnetisation of the coil upon the iron in this direction (dotted lines). In other words, by removing the iron, not too far away, and again not too near, whether you do not get an external magnetisation of the iron lying close up to the exterior of the coil, which would make up for part of this loss by short-circuiting from proximity of iron to the field pole.

With regard to the use of long or short magnets in the dynamo, if we take into consideration what I have just stated in regard to the magnetising power of the armature, it will depend upon the diameter of the armature, and the length of the magnetic conductor that is in the armature. Assuming the armature to be made up of radial bars, or even discs, the length of magnet you will have to employ will depend upon the opposing magnetic effect of the armature, and I may say also, to the distance between the field magnet and the armature. If you wish to get reaching power or depth of field, in order to reach any distance through the armature, the iron being far away, you will have to use long magnets. If you have an armature which has long projections, making an approximate contact, you can use much shorter magnets with equal results.

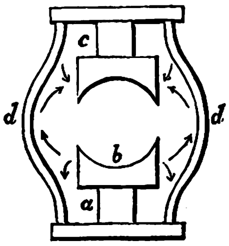

FIG 6.

In regard to the use of steel magnets, it is well known that steel in no condition can accept as much magnetism as soft iron, and it is also well known that if you harden the exterior of a magnet having soft-iron interior, that the radiation to the soft-iron interior of the magnetic lines will cause a short circuit of magnetism through the interior of the magnet. So I do not think we can look for any improvement over soft iron for field magnets. There are many other considerations that might be noticed which show economy lies in using soft iron only where we wish to get the greatest available magnetic strength.

I cannot agree with either of the gentlemen who preceded me in the statement that there is dead wire in the Gramme armature, or in any other armature that encloses a magnetic circuit. If that was the case, then all wire upon bobbins would be dead wire. We could not produce a dynamo machine which had bobbins in it (for what is the Gramme ring but a series of bobbins), which when they pass the field poles—those bobbins are magnetised there in that manner just as they are in the old Holmes and Alliance machine—when they pass from the position where they include the greatest number of lines of force, pass from the position of saturation to the position of less saturation; they go over to a position where the saturation is reversed. What suggests the reason that the outside of the wire would be more efficient than the inside wire is simply because, as I look at it, there is a tendency that is unrestrained for the armature to kill itself while it is passing at this point (indicating). There is a tendency of the armature to magnetise the magnet, making a closed circuit on the inside of the ring, which diminishes the effect of it on this

* Discussion on Papers read at the Congress of Electricians at Philadelphia.

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wire. However, this closing of the magnetic circuit on the outside of the core causes the field magnet to lose control of the direction of the lines of force. This closure of the circuit on the inside of the ring, however, is simple and easy to take place, because here the iron is practically removed from the powerful control of the field magnet, and the coils are where they can act as magnet coils to close their own circuit. How can we increase the efficiency of such a machine? Evidently we can prevent that closure by putting some more magnetic material there.

There is an effect in such machines to which attention has not been called. It is that we can take the same sizes of wire applied to a larger machine and exhibit a real and theoretical increase of efficiency. I hold, however, that theory, when it is true and complete, always coincides with true and complete practice; there is no intermediate stopping point. If you take into consideration every variable, you are bound to arrive at the complete practice; you cannot have one thing theoretical and the other practical. It has been proved mathematically, and it is very easy to go over the ground, but I will not take your attention now, that if we use the same size of wire on armature and field we have the power of the machine increased as the fourth power of its linear dimensions. But if we attempt to apply that in practice, we find this: that the surface of the machine clearly increases as the square of the dimensions, whereas the cubic capacity—in other words, its power to retain heat—increases as the cube of its dimensions. The result of that is that in a large machine you will have to provide a greater amount, proportionately, of cooling surface, or enlarge the size of the wire. The power of the dynamo run for series lighting (I may say I have only determined it approximately) increases as the cube instead of the fourth power of the linear dimensions.

In the study of the Gramme armature and its method of commutation I think we have yet to learn a great deal. I cannot see any reason why in the Gramme armature during the commutation there should be any loss at all. Let us figure the ring and study the action of commutation. A coil goes out and comes upon the commutator, passes it and returns, and so on. I hold that the period of contact is such that if the brushes upon these segments are properly arranged there will be no loss; in other words, the time of contact that must exist between these two segments and the brush will be the time that it takes for the coil to lose its current; the commutation must not occur at any other time than when the coil is ready to lose the current and acquire current in the opposite direction of the same amount it is to take when the break shall be made. I do not know that I have made that perfectly clear, but I will go over it again. If the contact remains for a sufficient period to allow the coil to lose its current and the commutation is only being made while it is running down in electromotive force, and continues until the current rises on the other side, until it is fit to go into the circuit; in other words, until it just conducts the current that the other side demands, you will have no loss from commutation. Make it just at that period, and where is there any loss?

In regard to the resistance of armature coils, I think there is an effect that is generally omitted in considering dynamo machines, and it is this—that we cannot consider the measurements of the resistance of the armature at any time as the working resistance. We cannot measure it in any position and let that be taken as the resistance of the armature coil when it is working. Why? Because in any dynamo that furnishes us continuous currents we will have this condition sometimes existing. That is, in the Gramme we have constantly two series of coils; in the Brush, two series of coils, put in multiple arc at times. If you measure the machine while not at work you take it for granted that the current when the machine is running will be equal in those two branches.

Will it ever be equal in those two branches? The energy developed by that armature will depend upon whether the current divides equally for the time being. In other words, whether the ring is equally balanced, or whether the brushes are of equal temperature, or whether the armature is put at the centre of the field. The wire will become more energetic if it is nearer the field pole than the under side, and the effect will be that you are sure to displace your commutator brushes. More current will pass through one side than through the other, and you will have more heat developed in one than in the other, and you will not have a perfect dynamo. You will have more energy consumed in that dynamo; and I may say that there is not a machine that I do not regard as coming under that condition. You measure the resistance of the machine when still, and you will not have the same resistance when running it, because the currents do not divide as in still resistance.

That is about all I have to say in regard to the subject under discussion, except that if I have an opportunity I should like to call attention to a number of other matters that affect the working of dynamos. These matters have been derived from studying dynamos and making very many types of machines and experimenting with them, my whole time being almost entirely devoted to their study.—*Electrical World.*

THE DISRUPTIVE DISCHARGES FROM THE HOLTZ MACHINE.

M. Jamin lately presented to the Paris Academy of Science, a paper on this subject, by the Abbé Maze, of which the following is the substance:—When a Holtz machine is employed, the exciter of which is so constructed that the spark may be drawn, at will, to the right or left of the axis of the apparatus, it is found that the position to be given to the movable part of this exciter is far from being a matter of indifference. Thus, if the movable part be left complete with its balls and its condenser; if, besides, such a position be given to the two movable branches that the ball which disengages the positive electricity be nearer its condenser than the other is from its condenser; in a word, if symmetry be broken by carrying the opening of the balls from the positive side, there will be obtained, with a mean distance between the two, two narrow brush discharges of unequal length, the larger corresponding with the positive pole. These brush discharges do not unite, but produce slight dull detonations. If, without in any way modifying the rest of the machine, the side of the opening be changed, so that the positive conductor be the longer, the phenomena become quite changed.

It is no longer possible, whatever be the distance between the balls, to obtain detonating discharges, but always the ordinary crackling spark. The absence of symmetry may also be demonstrated by removing the ball of the positive pole. If, in that case, the interception be on the side of the negative pole, the discharge will attain at most half the preceding length. If the ball of the negative pole be removed, the influence of symmetry will not be so manifest. These experiments may be repeated after removing the condensers, when the phenomena are generally of the same order as in the former case, but much less intense. Besides, it is not only optical phenomena which prove the importance of the question of symmetry, mechanical facts lead to the same conclusion. In fact, if, after having deprived the exciter of its balls, a strip of paper 10 centimetres by 20 centimetres be suspended between the points, with the opening on the side of the positive pole, the paper will be strongly repelled by the negative pole; but, on the other hand, if the interruption take place on the negative side, the paper will be repelled by the positive pole.

This experiment succeeds with or without the condensers; but the result is more strongly marked when they are suppressed. It is worthy of remark that if the branches of the exciter are placed symmetrically with respect to the axis of the machine, repulsion is manifested by the positive pole when Leyden jars are used, and by the negative pole without them. In conclusion, the Abbé Maze remarks that he has confined himself to simply stating facts, without formulating any theory; but he considers that the causes of the phenomena observed are to be sought in a reciprocal induction of the various parts of the machine.

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EXTRACTION OF METALS BY ELECTRICITY.

In the November number of the *Chemical Society's Journal* is the following abstract of a paper originally appearing in *Dingler's* No. 253 :—

R. P. Hermann treats zinc ores with acids, and precipitates the metal electrolytically, after converting it into a double alkaline. M. Kiliani proposes to extract calamine, zinc-ash, &c., with ammoniacal liquor containing carbonate, and then to precipitate electrolytically, employing iron anodes. M. Body recommends mixing the powdered ore with ferric salts alone, or with the addition of common salt, by which advantage is taken of the property of ferric salts to pass into the ferrous state in the presence of metallic oxides or sulphides, under the influence of an electric current. This change leads to the solution and precipitation of the metal; subsequently the ferrous salt can be readily converted into the ferric state, and is again ready for use. The finely powdered mineral is exposed in moist heaps to the action of the air and repeatedly ground. The ore may then be placed in a tank provided with a bottom of pressed coke, in which is embedded the negative pole of a dynamo, whilst the other pole is connected with the ore at one or more points. In treating certain ores of gold and silver a cast-iron drum is employed, which is connected with the negative pole of a dynamo, and is slowly revolved. Within the drum are several cast-iron balls. Through the drum, and isolated from it, passes a fixed axle, which is connected with the positive pole of the machine, and which carries a series of coke or graphite plates dipping into a solution of ferric salts containing the mineral. The axle is hollow, and serves for the introduction of liquid to the drum; a steam-pipe, terminating within the liquid, also passes through it. When the silver is reduced, mercury is passed into the drum, and the amalgam is collected in the ordinary way. The method is advantageous for ores which contain only 0·05 per cent. of silver.

BUCHAREST.

Mr. Jehl, who carried out the work of lighting the Bonn Theatre for the Edison Company, is now engaged in similar work at the Bucharest Theatre National. This theatre will be fitted throughout with the Edison system, using the 10-candle lamps. There will be four dynamos of 300 A lamps (16 candles), but as 10-candle lamps will be used each machine will have to supply current for about 450 10-candle lamps. These 10-candle lamps are held to be very economical, having a high resistance and using only ·5 of an ampere current. The machines will be driven by two high speed steam engines, viz., one Porter-Allen, and one Armington and Sims. The dynamos, steam engines, and boilers will be placed in the front cellar of the theatre, just underneath the entrance. It is singular that this order was received by the society in Paris, through the director Bouron of the Bucharest Gas Company, a man who fully appreciates the new improvements in illumination, and does not let prejudice work against them. If all gas directors were of such honest opinions, there would be less *gasing* (figuratively in the conflicts between gas and electric light) and more electric light. The theatre will also have the various regulators necessary for the production of effect lighting. Red and green lamps will be placed on the stage. The following list shows somewhat the number of lamps intended to be installed :—

Stage Cross Lights.

No. 1.	26 red lamps,	26 green lamps,	26 white lamps.
No. 2.		ditto	ditto
No. 3.		ditto	ditto
No. 4.		ditto	ditto
No. 5.		ditto	ditto
No. 6.		ditto	ditto

Stage Footlights.

Right—	28 red lamps,	28 green lamps, and	28 white lamps.
Left—		ditto	ditto

Stage Uprights : 12 pieces, with three lamps each.

Stage Portable Stands: Two pieces each having eight lamps, making a total number on the stage of 688 lamps.

The auditorium is divided into two circuits, one circuit having a total number of 369 lamps, which are used every night, and are divided in various parts of the auditorium. The other circuit forms what is called the "gala" lighting, used when the king comes to the theatre. There are 307 extra lamps in the second circuit, making a total number of 676 lamps in the auditorium burning when His Majesty comes to a performance. Then there are lamps in the salon, vestibule, grand foyer, &c., in fact all over the building where gas is now used, to the number of about 370 lamps. Summing up this gives to the stage 688, to the auditorium 676, to the other parts of the house 370, making a grand total of 1,734 lamps. However, as the red and green lamps are not always used at one time, the total number of lamps burning will be reduced to 1,512 lamps.

Besides the above the new baths are to be lighted by the Edison system. This is a very large building in the course of erection at Bucharest. There will be used 1,000 Edison A lamps driven by four dynamos of 300 lamps each ; one can then swim by the electric light, and in winter the large basin will be converted into a ball room.

THE USE OF ELECTRO-MAGNETS FOR RAILWAY SIGNALS.*

BY ILLIUS A. TIMMIS.

[Some of our readers may remember an article on "Electric Railway Signals" which was given in our issue for March 22, 1884. The paper of Mr. Timmis refers, but far more fully, to the system described and illustrated in our article. This being the case we must refer our readers to pp. 439—443, Vol. XII., for some of the illustrations, which for reasons of space we cannot this week reproduce ; nor are those reproduced drawn to the scale mentioned in the paper.—Ed. *E.*]

The object of the present paper is to describe a new, powerful, and economical electro-magnet, capable of exerting its pull in a manner suitable for convenient application to the mechanical working of railway signals and points. Its main features are its great power, which is exerted through a long range, and is under perfect control; and its economy, both in exerting the initial pull which effects the mechanical movement required, and also in retaining the moving parts after the desired movement has been effected.

The rapid growth of railway systems, and their consequent complexity, have rendered urgent the application of electricity for the working of railway signals and points, and for checking the work done by signalmen and pointsmen. Though much has been accomplished in this direction both in this country and elsewhere, there has hitherto been always one initial want, namely, an electro-magnet, which, with a low average current and a small electromotive force, shall give a powerful, long, and well-balanced attractive pull. A range of pull of only half an inch, which has hitherto been the practical limit with electro-magnets, is evidently not long enough to be of use for heavy mechanical work, such as pulling signal-arms over or throwing machinery in and out of gear; and although the range can be increased by multiplying gear up to two or three inches, yet the increased current then required for making the attraction powerful enough at the initial half-inch distance is so enormous that two difficulties present themselves which are almost insuperable—firstly, the expense; and, secondly, the destructive violence of the final impact, in consequence of the attraction increasing inversely as the square of the distance of the armature from the magnet, and for part of the stroke inversely as the cube.

In the ordinary form of the electro-magnet, a core or bar of soft iron, wrapped round with a coil of wire or tape, and bent into the shape of a horseshoe, attracts to its poles a plain armature; and, by some natural law, as yet unsolved, the working pull of such a magnet practically ceases, as already stated, when a distance of only half an inch between the magnet and the armature is exceeded. In the electro-magnet of tubular form, thence called a *solenoid*, a hollow core or tubular bobbin of brass is wrapped round with wire or tape; and a central rod of soft iron, sliding lengthways inside it, forms the armature, which is drawn or sucked longitudinally into the core by the attraction of the bobbin coil, until it reaches a central position in relation to the magnetic field; in this position the attraction is symmetrical in all directions, and is therefore neutralised. Although a considerable length of attractive pull can be got with such a magnet, the current of electricity required to give any strong initial pull is so excessive that its cost is prohibitory; moreover it is clear that the holding power falls to zero when the armature reaches its central position longitudinally. In order to obtain adhesive power, or what is called a "retaining" pull, the internal sliding rod or armature is made shorter than the length of the hollow bobbin, and is capped at one end with a disc of soft iron, which, coming in contact with that end of the bobbin, thereby prevents the armature rod from reaching its central or neutral position within the bobbin, and leaves a corresponding reserve of holding power against the end of the bobbin.

Currie Long-Pull Magnet.—In the long-pull electro-magnet, shown double full size in the accompanying diagram (Fig. 1), which is the invention of Mr. Stanley Currie, the principle adopted is a combination of the horseshoe magnet and solenoid, with additions; but the con-

* A paper read before the Institute of Mechanical Engineers, on Wednesday, November 5th, 1884.

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struction is so materially modified as to give far greater power and efficiency, and the magnetic attraction is more evenly distributed over a longer range, while the initial pull is stronger and acts at a greater distance than in any other electro-magnet of the same weight and with the same current. The range already attained in practice is 3½ inches, and can be increased.

The bobbin B, here shown standing upright on one end, is made with a tubular core, C, of soft iron; and the coil of wire wound around it, coloured red, is surrounded by an outer casing of soft iron, B, of the same weight as the core, with a soft-iron base-plate at the bottom of the bobbin, connecting the core with the outer casing; a brass plate covers the bobbin at the top. The copper wire used in the coil is No. 18 Birmingham wire-gauge, or 0·048 inch thick. The armature consists of three portions, each one playing its part in the work to be done. The central stalk A of soft iron is rather shorter than its own range of motion, and is encased in a brass tube, which is prolonged below it so as to form a guide, fitting within the bobbin core. The soft-iron cap or disc D, fastened on the top of the central stalk, is slightly larger in diameter than the outer casing of the bobbin B. It is made by preference of two or more thicknesses of flat plate, to assist in demagnetisation; but it must be thick enough to prevent saturation with any working current. Round the edge of the disc runs a cylindrical rim or flange, F, projecting downwards; it is so shaped as to suit the attraction required, and it comes within the range of attraction of the outer casing of the bobbin when the lower end of the central stalk has entered within the core. When the rim in turn has done its duty, the disc D comes within range of attraction of both outer casing and inner core.

Uniformity of Pull.—So long as the central stalk or armature rod is altogether out of the bobbin core, the attraction upon it continues to be inversely as the square of its distance from the bobbin; but as soon as the end of the iron rod enters within the orifice of the core, the force of attraction becomes lost upon so much of its length as is inside the core. The same diminution in attractive force holds good in regard to the flanged rim of the armature disc, as soon as its lower edge passes below the upper edge of the bobbin. The force of attraction varies also directly as the mass of the body attracted. Advantage is therefore taken of these two principles in combination, to regulate or adjust the effective attraction in such a way as to obtain some sort of approximation towards uniformity of pull throughout the 3½ inches range of stroke of the armature. This is accomplished by tapering, in the manner shown in Fig. 1, the lower end of the armature stalk A, and also of the flanged rim F, according to the desired adjustment of the attractive force; in addition to which the thickness of the armature disc D and the distance that its flanged rim F projects downwards, as well as the thickness of the rim, can also be varied; and in some cases, moreover, as in some of the examples shown in drawing 9, the bottom edge of the flange is made of a serrated or wavy form, so as to prevent the pull from suddenly increasing as the disc nears the bobbin. The result is that, when the strength of the pull on the armature stalk and flanged rim is decreasing, owing to their having both of them reached and passed the position of maximum attraction, the pull on the disc is increasing as it nears the magnet head. In this way, and in combination with a counterweight acting at a suitably varying leverage, an approximately equal pull is obtained through a considerable range, and violence of contact in the closing of the disc upon the magnet is avoided. By suitably adjusting the several proportions of the various parts, the pull can be so greatly varied both in force and range that it can be adapted to meet almost any requirements.

Double Length of Pull.—A double length of pull is readily obtained by the simple tandem combination shown half full size in Fig. 3. Here a pair of single magnets on the foregoing principle, arranged at a fixed distance apart, have their armature guide-rod, B, in common; the lower armature-disc L is made fast upon the rod, while the upper disc U bears against a shoulder upon it. The range of the lower disc being nearly double that of the upper, the first half of the pull is given by the upper; and by the time the upper disc U has closed upon its own bobbin, it has brought the lower disc L within the attractive range of the lower magnet, by which the second half of the pull is then given, the armature rod R now sliding free through the upper disc U. This arrangement is suitable for working signal-arms that are required to stand at the three positions of danger, caution, and line clear, as shown in Fig. 3.

Railway Signals.—In the application of the electro-magnets to railway signals, the ordinary signal posts and arms are utilised; but it is advisable that the bearings and working parts should be made as true as practicable, because, though friction is not so material when the work is done by manual labour, it is of the utmost importance that it should be reduced to a minimum where electricity is the motive power. As there are no complicated parts, and the movements are all simple and direct, there is no difficulty on this point.

In the accompanying drawing (Fig. 2) is shown the application of a single magnet to an ordinary signal-arm intended to stand in only the two positions of danger and line clear. The magnet M is fixed upright on a bracket at the back of the post, and a chain from its armature pulls upon a quadrant arc centred on a horizontal spindle above it. The quadrant carries a lever and counterweight, W, acting in opposition to the pull of the magnet; and also an arm which is connected by a rod, coloured red, with a bell-crank centred at the side of the post. Another rod, coloured blue, connects the bell-crank with the semaphore and spectacle. When the magnet is out of action, the semaphore is held up at danger by the weight of the spectacle, in conjunction with the counterweight W on the quadrant lever, which then comes against a stop. In this position all the parts are locked, in consequence of the quadrant arm being then on its dead centre; that is, the quadrant arm and bell-crank are so arranged that the direction of the rod (coloured red) connecting them passes then through the centre on which the quadrant turns. For yet greater security of locking, it is preferable, indeed, to let the connecting-rod be even a trifle beyond the dead centre, so that any pull upon the bell-crank, from wind pressure or accumulation of snow on the semaphore, shall hold the counterweight lever W still more firmly against its stop. The locking is thus done mechanically, and is independent of the magnet. On bringing the magnet into action by a current from the signal box, the pull of the armature rotates the quadrant arc, raising the counterweight and spectacle, and lowering the semaphore; in this position the semaphore is retained so long as the electric current is continued. On the cessation of the current, the semaphore is automatically raised again to danger, and locked there mechanically without the use of extraneous catches, which is a most important feature.

In Fig. 3 is shown the application of the double magnet or tandem arrangement to a balanced semaphore centred at mid-length. Here the pair of magnets are fixed on one side of the post, and the quadrant arc on which they exert their pull is fixed on the spectacle spindle. A rod (coloured red) connects the spectacle with a crank on the semaphore, and the weight of the spectacle brings the semaphore to the horizontal position of danger, in which it is locked mechanically as before, by the connecting-rod being then on its dead centre. An electric current sent to the upper magnet pulls the semaphore to an angle of 45° for caution; and a second current sent to the lower magnet pulls it vertical for line clear. In either position it is held by the spectacle acting as a counterweight against the retaining pull of the magnet.

Electric Current.—Under ordinary circumstances a current of 3 amperes is amply sufficient to pull the armature down upon the magnet, and so actuate the semaphore; but to guard against wind pressure, dust, rust, and wear of rubbing parts, a current of 5 amperes is provided. In addition a reserve current of as much as 15 amperes is kept in store at the signal-box, and is at the immediate command of the signalman in any emergency. From the red line in the diagram shown in Fig. 4 it will be seen that with 5 amperes an initial pull is given of 8lbs., at a distance or range of 3½ inches; which is more than double what is required to work any signal arm properly fitted; and the home pull is 321lbs.

If the same strength of current were necessary to hold signals down as to pull them down the use of a continuous current would be prohibited by its cost. But a current of only 0·1 ampere is more than sufficient to hold a signal down; and it is found that a continuous current of 5 amperes for moving the signal, and of 0·1 ampere for retaining it, yields an economical result. Accordingly when the armature has finished its stroke and moved the signal, it is made to switch in automatically a resistance-coil which reduces the maximum or moving current of 5 amperes to the minimum or retaining current of 0·1 ampere. The resistance-coil can take the form of an incandescent lamp, which then serves as an indicator or tell-tale in the signal box, as shown in Fig. 5.

In excess of the greatest possible requirements, it may be assumed that the whole time during which each signal is needed to be held down to show line clear is 12 hours out of every 24; and that the number of times each signal has to be lowered in the 24 hours is 150; and that the time occupied in each lowering is 2 seconds. Assuming also 10 amperes instead of 5 as the moving current, and 0·2 ampere instead of 0·1 as the retaining current, then 150 lowerings × 2 seconds × 10 amperes = 3,000 ampere-seconds or 0·8 ampere-hour; and a retaining current of 0·2 ampere for 12 hours = 2·4 ampere-hours; the total is therefore 3·2 ampere-hours of current C per signal per 24 hours. The resistance R being taken at 5 ohms, the electromotive force E is equal to $C \times R = 3{\cdot}2 \times 5 = 16$; and assuming 746 watts = 1 H.P., the horse-power is equal to $C \times E \div 746 = 3{\cdot}2 \times 16 \div 746 = 0{\cdot}07$ H.P. The cost of providing a current of such power by means of a secondary battery, according to well recognised electrical data, would be only 0·4 penny; while the current actually used being only about one-third of that provided, and the real time less than one-half, the true cost would be less than one farthing per signal arm per day.

The foregoing remarks respecting the electric current employed to actuate the magnets apply to the use of secondary batteries; and the results obtained from these accumulators of electrical power are very satisfactory and economical. In certain cases, however, it may be preferred to use a primary battery, such as the Lalande oxide of copper battery, the working of which is very easy and reliable. The constant and economical current it gives can be used not only for actuating the magnets, but also for lighting the lamps on the signal posts and at the points. With a primary battery, the reduction of the current from a moving to a retaining current cannot be effected in the same way as with a secondary battery, by switching a resistance in; but the same levers and switches are still available for switching *out* the large battery which gives the stronger moving current for lowering the signals, and switching *in* a smaller battery, of smaller cells and with greater internal resistance, which gives the weaker retaining current for holding the signals down.

Railway Points.—In Figs. 6, 7, and 8, are shown full size the magnets and gearing for working a pair of railway points; these magnets are practically of the same construction as for working signals, but are of larger size, and are wound with copper tape instead of wire in order that they may take a maximum current with a minimum of resistance. With a current of 23 ampères and an electromotive force of 40 volts, the force of the pull is as shown by the blue line in Fig. 4, commencing with an initial pull of 33 lbs. at 3½ inches distance, and increasing to 54 lbs. at 3 inches, and to a home pull of 1,064 lbs. As will be seen from the diagram, the points are pulled over and held in either position by the sliding rod R, which is worked by the lever L, and is locked by the locking bolt P. The slot in the rod R is made ½ inch longer than the width of the lever L working in it, so that the first ½ inch of travel of the lever withdraws the locking bolt P by means of the incline I on the extremity of the lever, before the lever acts upon the sliding rod R.

Where a pair of points are covered by a signal, the locking bolt P—in conjunction with the armature of the magnet which pulls the points over into the position corresponding with the signal when down for line clear—

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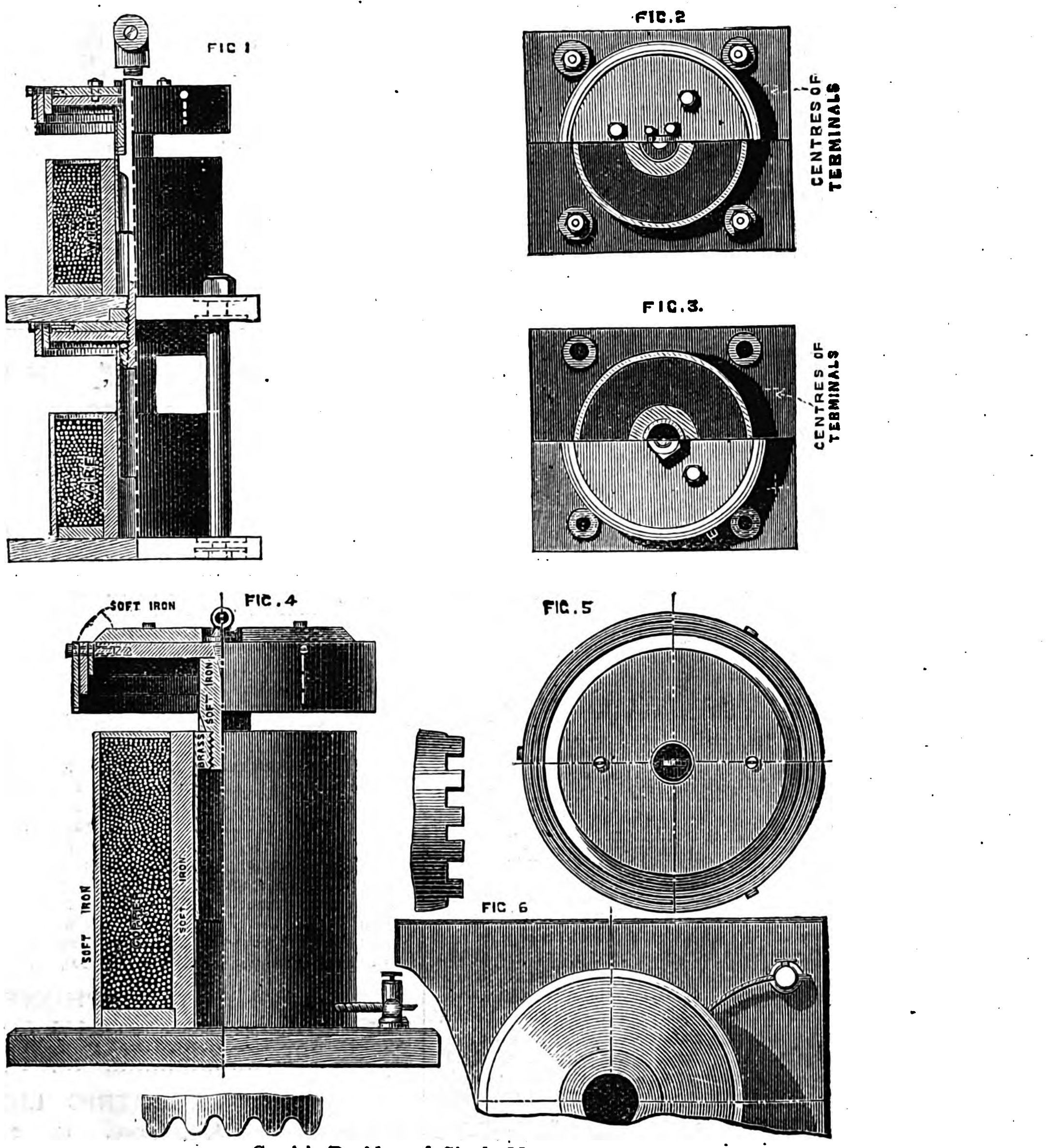
completes the circuit which enables the signalman to lower the signal. The signal is checked by its automatic repeater in the signal box. The other point-magnet completes with the locking bolt the circuit which works a repeater in the signal box.

Advantages.—The advantages of working signals and points by this system are that their distance from the signal-box is immaterial, inasmuch as the electric working gets rid of all the mechanical difficulties which arise from excessive expansion and contraction of lever wires and from the severe pull required to work them through long distances.

Signals.—It is only during the continuance of the electric current that the signal can be held at caution or line clear; its normal position is at danger, to which it returns automatically on the cessation of the current, or if anything goes wrong; and in this position it is locked by simple mechanical means, and not by any electric agency whatever. Each signal is worked by its own magnet, and has a repeater or tell-tale in the signal-box in the shape of a small arm, R (Fig. 12) which shows the position of the signal-arm. If it is desired, the repeater is arranged to show the exact travel of the magnet armature working the signal; that is, if the armature provide a perfect check, without the intervention of manual labour or the will of the signalman.

Application to Railway Junctions.—In Figs. 10, 11, and 12 is given an illustration of the application of this electric system to working the signals and points of an ordinary junction where there is a double line of way both on the main line and on the branch. The signal-box is here divided, as regards the electrical connections, levers, and switches, into thirteen divisions, 1 to 13.

Suppose an up main-line train is required to be turned into the branch (Fig. 10) it will be necessary to work the points P 6, and the three signals on the up main line, namely the distant signal S 1, the home signal S 3, and the station signal S 5. The lever of the points P 6 is first pulled over in division 6 of the signal box, whereby an electric connection is made between 6 and 7, the up-branch points being thus set right for the up train to pass into the branch. The down branch point lever 8 must be back or in its normal position in order to let the current pass through to division 3 for lowering the home signal S 3. As soon as the signal lever is pulled over and the signal lowered, the current can pass on to 1 for enabling the



Currie's Double and Single Magnets.

stops half way, the repeater arm would stop in the same position; in fact, any arrangement that may be desired can easily be effected. At the instant of contact between the armature and the magnet there is a momentary cessation of the main current, and the tell-tale arm indicates this by falling back a little from its extreme position. This affords another infallible check as to the correct working of the magnet. The reduction of the current from a moving to a retaining pull takes place automatically at the moment of the armature reaching the magnet.

Points.—The advantages in working points by these electro-magnets are as great as in the case of signals. Either can be worked at any distance from the signal cabin. There is no need for a cabin to be put up, or a stand of levers, to work any special set of points and signals; any number of points and signals can be worked from a small cabin, and can be locked and interlocked with absolute certainty. They can be so arranged that, if any wrong lever is moved by the signalman in arranging any combination, an alarm bell is rung in the cabin, and the signals already lowered go back to danger; the mechanical and electrical parts being so arranged as to

distant signal S 1 to be lowered. Last of all the current can pass to 5, lowering the station signal S 5.

Suppose another case of a train approaching the junction on the down branch to pass upon the down main line; the home and distant down branch signals S 12 and S 13 will have to be lowered. The points P 8 must first be in their normal position, and their lever 8 must be back, before the electric current from the battery can pass through 8 to 12, and thence to 10 for lowering the home signal S 12, and afterwards to 13 for lowering the distant signal S 13. It is now impossible to lower the home and distant signals S 10 and S 11 of the down main line, because the current for working these signals is prevented from passing by the act of pulling forwards the lever that belongs to the home signal S 12 of the down branch.

For station to station signalling (Fig. 11) the transmitter and receiver instruments are used in somewhat the same way as in ordinary railway working. The continuous current used makes the working very simple and easy and reliable. The signals and points are actuated by a main

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current, and this is checked and controlled by a subsidiary current, which works the transmitter and receiver instruments. A train travelling along any section of the line protects itself by passing over contact levers or treadles, T, both on entering and on leaving the section; the depression of the treadles by the deflection of the rail breaks the current, which holds the signal arms down, and sets them free to fly up to danger automatically.

COMPANIES' MEETINGS.

Brazilian Submarine Telegraph Company (Limited).

The twenty-second ordinary general meeting of the shareholders of this Company was held on October 31, the Right Hon. Viscount Monck in the chair.

The SECRETARY (Mr. Richard Collett) read the notice convening the meeting and the minutes of the last meeting, which were confirmed and signed by the Chairman. The report of the Directors was taken as read.

The CHAIRMAN reminded them that when he addressed them at that time a year ago he was obliged to give them rather a dismal account of the affairs of the Company. Their cables were at that time interrupted, their business was suspended, and their receipts were annihilated for the moment. He was very happy to state that on the present occasion he could completely reverse the picture. Their property was in every respect in an admirable state, they had a complete and, he believed, an excellent duplicate cable laid, and their old cable was known to be in good condition —not merely from the scientific tests by which that state of things was usually ascertained, but by actual inspection, for they had had occasion, in consequence of breaks in the cable, to lift it in different places three times within the last year. On every occasion the cable lifted appeared to be in as good condition as when it was submerged, except where the outer covering had been destroyed by the friction of the cable on a foul bottom. Two of the breaks had occurred from this cause, but they were unable to account for the other break in any other manner except in connection with the extraordinary volcanic actions which prevailed during 1883 all over the world. With regard to the income of the half year, the cable was interrupted between the 2nd and the 28th of March. That was before the second cable was completely laid, and of course there was a diminution in the receipts. Allowing, however, for the period during which the cable was partially suspended a receipt equal to the weeks immediately succeeding the suspension, the income of the past six months would equal that of the corresponding period of 1883. It might be said that this showed no growth in the receipts; but he did not think that could be correctly said, for the equality in the receipts of the two periods had been obtained in the past half year contemporaneously with a reduction of the tariff and with the competition for the carriage of messages to and from Chili and Peru by what was called the West Coast route. As to the expenditure, there had been an increase in the past half year, as compared with the previous six months, of £641, but in this was included the cost of the repair of the cable in March last, which came to £760. In point of fact, therefore, the direct expenditure on working expenses had been about £120 less than that of the preceding half year. When he addressed them a year ago he announced that they were about to duplicate the cable, a policy to which, he frankly confessed, he gave his adhesion with some misgiving. He had felt loth to put their reserve fund in the sea until it had become necessary to have a second cable, one cable in good condition being abundantly sufficient for performing the work. He had therefore been rather opposed to the duplication at first, but he had given way to the arguments of his colleagues, and he was now very glad that he had done so. The events which had since occurred, in connection with the breaks to which he had referred, had entirely justified the policy which had been adopted. When the break occurred last March there was a loss of income, but when the breaks in June and July occurred, the second cable having then been laid, there was no inconvenience whatever, and their receipts went on just as before. When he announced about a year ago that they were going to duplicate the cable he told them that they would require for the purpose £250,000 —mentioning an outside limit—in addition to the reserve fund; but he was glad to state that the reserve fund, with the addition of only £150,000, had been sufficient. He told them at the time that they would be able to duplicate the cable without increasing the share capital. By raising the money as they had done, by debentures, they had merely created a debt, which they would be able to pay off, whereas had they increased the share capital they would have introduced what would have been practically a permanent participant in their dividend, and an element which must *pro tanto* have diminished the dividend. Their new cable was as perfect—and he was sure it was cheaper—than any cable yet laid, and he trusted that, operating through the two cables, they would enjoy practically as great an immunity from suspension of business and interruption as they had in the first ten years of their life as a single cable company. Bearing in mind the competition against which they had had to contend, and the reduction of the tariff, their receipts had really practically shown an increase in the past half year, and he trusted that this would go on. Without prophesying, he trusted that they would be able at least to pay what the shareholders had been in the habit of receiving the last four or five years, and to make provision which would enable them to repair any future break without drawing on debenture capital or loan of any other description. He trusted that the mode in which the directors had managed the business in the past ten or eleven years had been satisfactory to the shareholders. They began by giving a comparatively small dividend, and they were all aware that when the directors found they could safely do it they increased the dividend. They would go on in the same course, consulting not merely the temporary and fleeting interests of the shareholders, but the permanent and lasting good of the Company. He concluded by moving the adoption of the report and accounts, and the declaration of a dividend of 3s. a share, making, with the interim dividends already paid, 6 per cent. for the year ended June 30th last, free of income tax.

The VICE-CHAIRMAN (Sir James Anderson) seconded the motion.

Mr. W. GRIFFITH, after expressing satisfaction at the report and at the remarks of the Chairman, said he thought it would be very satisfactory to the shareholders to know if the income in the past three months had kept up.

The CHAIRMAN said he was very glad to answer the question. The receipts of the past three months had been almost identical with those of the same period of 1882. There had been a slight diminution, but October, November, and December were generally three of the best months they had. In reply to Mr. Hawkes, he added that the competition to which he had referred in his opening remarks continued. The resolution was then carried unanimously.

On the motion of the CHAIRMAN, seconded by the Hon. W. ST. JOHN F. BRODRICK, M.P., Sir Thomas Fairbairn, Bart., was re-elected to his seat at the Board, as was also Mr. Henry Daniel Gooch, on the motion of the CHAIRMAN, seconded by Mr. FREDERICK YOULE.

Mr. THOMAS BENSON next moved, and Mr. JOHN ANDERSON seconded, the re-election of the retiring auditors, Mr. Henry Dever and Mr. John Gane.

On the motion of Mr. GRIFFITH, seconded by Mr. BARRATT, a vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN returned thanks for the kind way in which the vote had been submitted and carried, and assured the shareholders that it would stimulate the Directors to further exertions on behalf of the Company.

The proceedings then terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. NOV. 5.		BUSINESS DONE WEEK ENDING NOV. 5. Highest.	Lowest.
Anglo-American	31,	32	32	31½
Do. Preferred	54,	55	55½	54½
Do. Deferred	7,	7½	7½	7¼
Brazilian Submarine	10⅞,	11⅛	11¼	10 15-16
Cuba	11,	11½	11¼	11⅛
Do. Preference	17,	18	17¾	—
Direct Spanish	3½,	4	3 9-16	—
Do. Preference	14¾,	15¼	—	—
Direct United States Cable	9⅞,	10⅛	10¼	10
Eastern Telegraph	11⅜,	11⅝	11⅝	11 7-16
Do. 6 per Cent. Preference	13½,	13¾	13¾	13⅝
Do. 5 per Cent. Debentures, 1899	104,	107	106	—
Eastern Extension	11¼,	12	12	11¾
German Union	9¾,	10¼	—	—
Globe Telegraph and Trust	7,	7¼	7 3-16	7
Do. Preference	12½,	12¾	12⅝	12½
Great Northern	13⅞,	14⅛	14⅛	14⅛
Indo-European	31½,	32½	—	—
Reuter's	7½,	8	8	7¾
Submarine	175,	180	177	175
West India and Panama	⅞,	1⅛	⅞	— xd.6s.
Do. 1st Preference	7¼,	7¾	7½	— x d.
Western Brazilian	6½,	6¾	6⅝	6 9-16
Western Union 7 per Cent. 1st Mortgage	120,	122	—	—
Do. 6 per Cent. Sterling Bonds	100,	103	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	5-16,	7-16	7-16	—
Oriental	⅛,	⅜	—	—
United Telephone	11¾,	12¼	12	11¾

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	1¾,	2	1⅞	—
Do. (fully paid)	3½,	3¾	3½	3⅝
Hammond Light (£3 15s. paid)	¾,	1	1	11-16
Swan	—	—	—	—
Maxim-Weston	3-16,	5-16	—	—

MISCELLANEOUS.

Telegraph Construction	34,	35	34¾	34½
India Rubber, Gutta Percha, and Telegraph Works	22½,	23½	—	—

TRAFFIC RECEIPTS FOR OCTOBER, 1884.

COMPANIES.	Oct., 1884.	Oct., 1883.	Increase.	Decrease.
Cuba Submarine	2,200	2,744	—	544
Direct Spanish Telegraph	1,794	2,115	—	321
Eastern Extension	41,357	39,174	2,183	—
Eastern Telegraph	53,865	47,624	6,241	—
Great Northern	26,000	—	—	—
West Coast of America	4,065	—	—	—

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